Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

# Estimation of COVID-19 Impact in Virginia

November 30th, 2022

(data current to November 26th – November 29th)

Biocomplexity Institute Technical report: TR BI-2022-1781

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# About Us

- Biocomplexity Institute at the University of Virginia
  - Using big data and simulations to understand massively interactive systems and solve societal problems
- Over 20 years of crafting and analyzing infectious disease models
  - Pandemic response for Influenza, Ebola, Zika, and others


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# Overview

- **Goal**:  Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project based on scenarios for next 4 months
  - Consider a range of possible mitigation effects in "what-if" scenarios
- **Outcomes:**
  - Ill, Confirmed, Hospitalized, ICU, Ventilated, Death
  - Geographic spread over time, case counts, healthcare burdens

# Key Takeaways

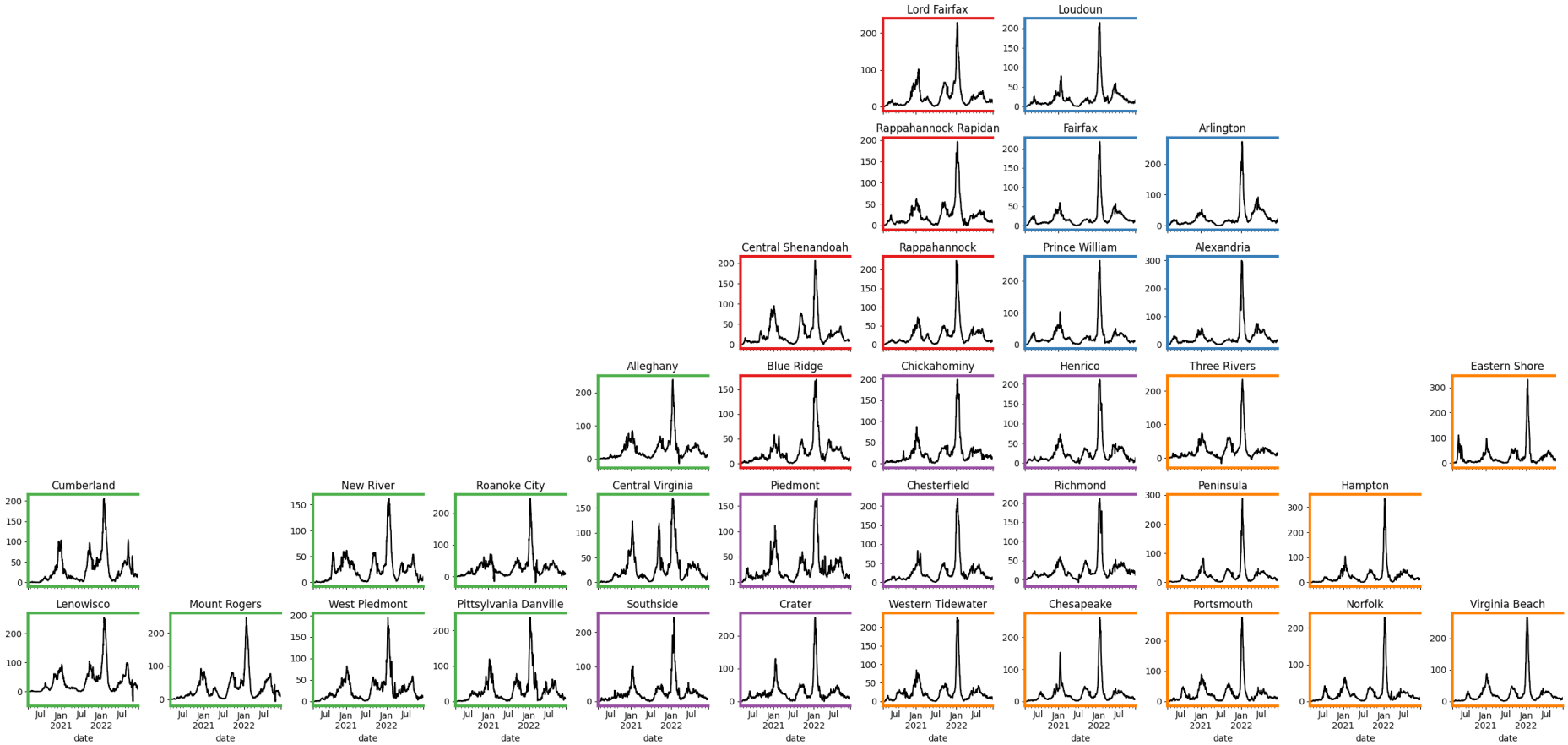
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

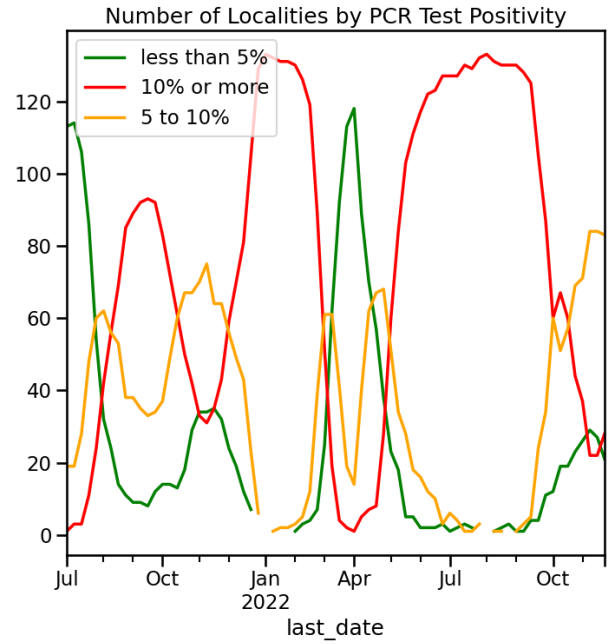
- **Case rates remain relatively flat though hospitalizations have experienced burst of growth in past week**
- VA weekly case rate is steady at 73/100K from 72/100K
  - US weekly case rate is flat remaining at 76 per 100K from 73 per 100K, though hospitalizations continue a steady rise
- VA hospital occupancy is quickly rising (rolling 7 day mean of 488 from 464 a week ago)
  - Influenza weekly hospital admissions remain high (~300 a week) and are approaching parity with COVID admissions (~40% of the combined)
- Projections anticipate increases in cases and hospitalizations in coming weeks
  - Combined hospitalizations due to Influenza and COVID-19 though are expected to level off
- Model updates:
  - Variant X candidates have now surpassed 50% (BQ.1.1, BN.1, BF.7 and others and XBB among others), 50% remains at Nov 12th
  - Modified Booster Scenarios: Current pace (included in all scenarios) with comparisons between keeping the pace (which is slowing) and a more Pessimistic scenario where vaccination halts at current levels

The situation continues to change. Models continue to be updated regularly.

# Situation Assessment

# Case Rates (per 100k) and Test Positivity




**County level RT-PCR test positivity**

Green: <5.0% (or <20 tests in past 14 days)

Orange: 5.0%-10.0% (or <500 tests and <2000 tests/100k and >10% positivity over 14 days)

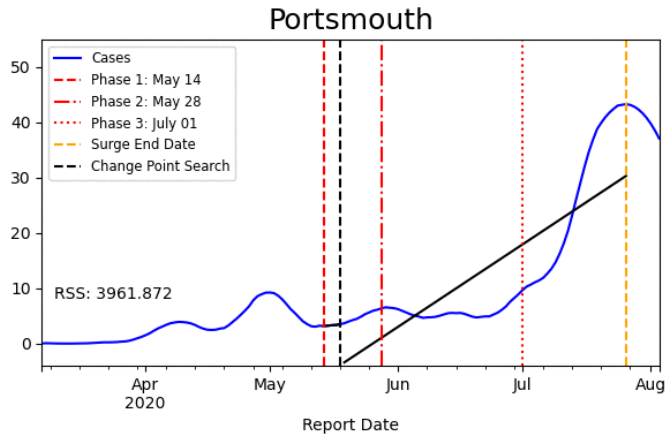
Red: >10.0% (and not "Green" or "Yellow")

# District Trajectories

**Goal:** Define epochs of a Health District's COVID-19 incidence to characterize the current trajectory

**Method:** Find recent peak and use hockey stick fit to find inflection point afterwards, then use this period's slope to define the trajectory

Hockey stick fit

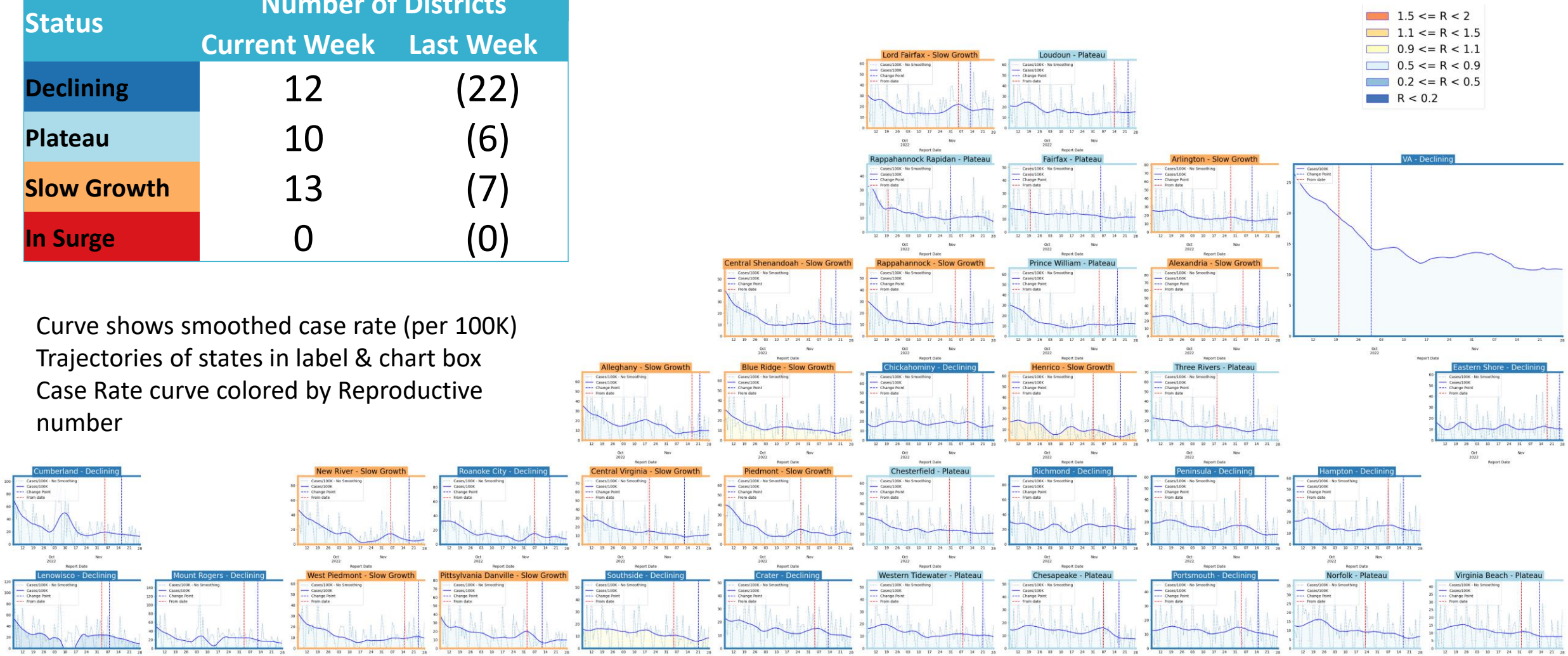



| Trajectory | Description | Weekly Case Rate Slope (per 100k) | Weekly Hosp Rate Slope (per 100k) |
|---|---|---|---|
| Declining | Sustained decreases following a recent peak | slope < -0.88/day | slope < -0.07/day |
| Plateau | Steady level with minimal trend up or down | -0.88/day < slope < 0.42/day | -0.07/day < slope < 0.07/day |
| Slow Growth | Sustained growth not rapid enough to be considered a Surge | 0.42/day < slope < 2.45/day | 0.07/day < slope < 0.21/day |
| In Surge | Currently experiencing sustained rapid and significant growth | 2.45/day < slope | 0.21/day < slope |

# District Case Trajectories – last 10 weeks

| Status | Number of Districts | |
|---|---|---|
| | Current Week | Last Week |
| Declining | 12 | (22) |
| Plateau | 10 | (6) |
| Slow Growth | 13 | (7) |
| In Surge | 0 | (0) |

Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive number



# District Hospital Trajectories – last 10 weeks

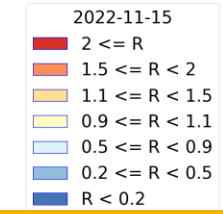
| Status | Number of Districts | |
|---|---|---|
| | Current Week | Last Week |
| Declining | 18 | (23) |
| In Surge | 1 | (3) |
| Plateau | 12 | (10) |
| Slow Growth | 4 | (0) |

Curve shows smoothed hospitalization rate (per 100K) by district
Hosp rate curve colored by $R_e$ number

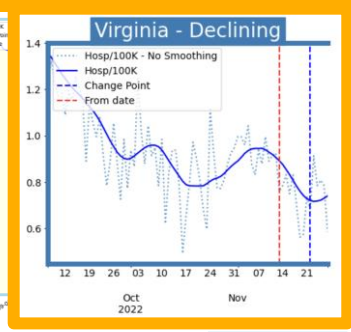
**Holiday reporting delay**

Hospitalization by county is delayed, these data are current as of

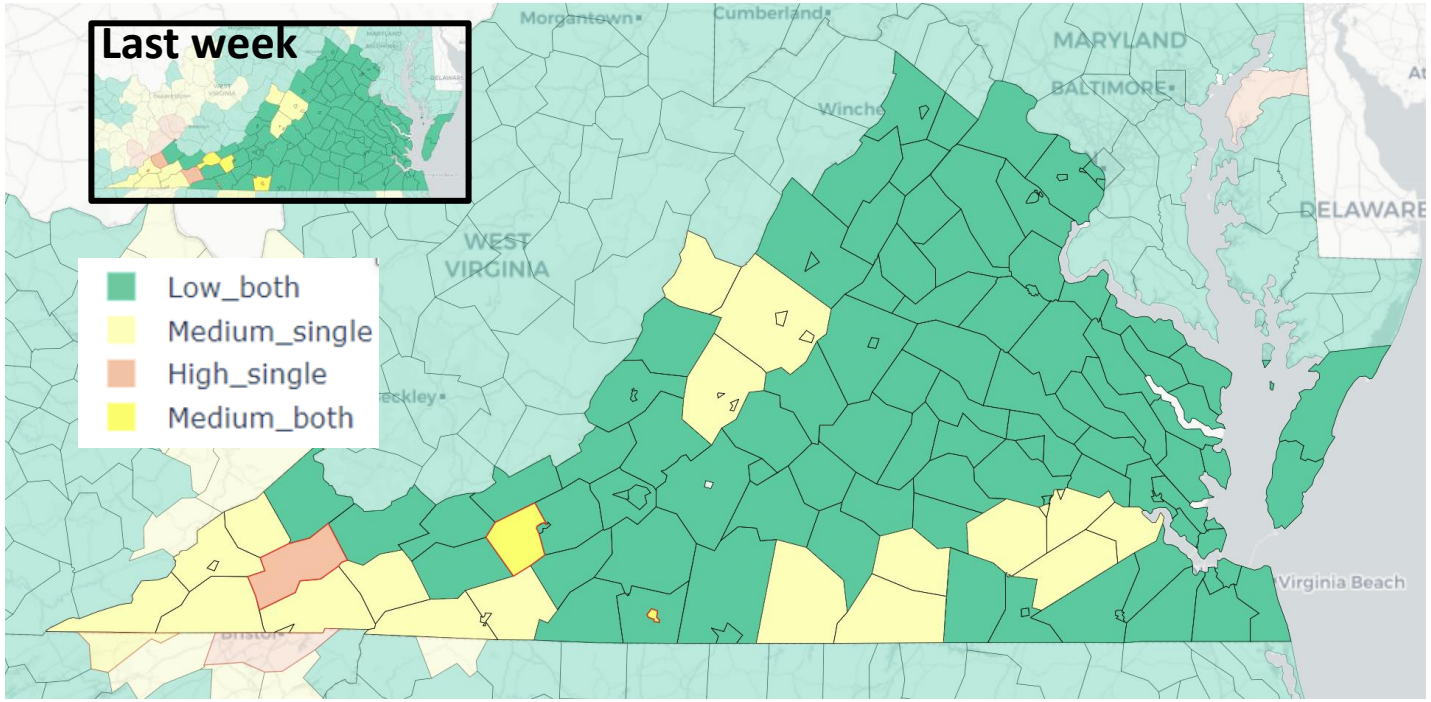
**November 15th**




**State level without delay**



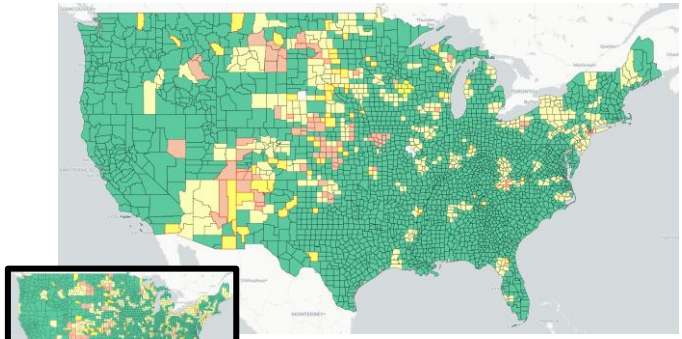
# CDC's COVID-19 Community Levels




**Red outline indicates county had 200 or more cases per 100k in last week**

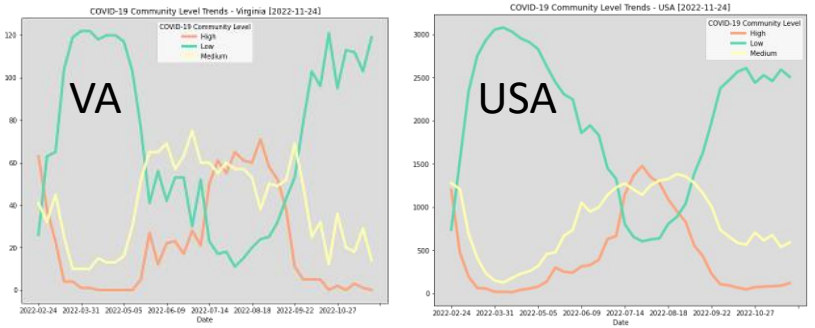
**Pale color indicates either beds or occupancy set the level for this county**

**Dark color indicates both beds and occupancy set the level for this county**





**Last week**




| COVID-19 Community Levels – Use the Highest Level that Applies to Your Community | | | | |
|---|---|---|---|---|
| New COVID-19 Cases<br>Per 100,000 people in the past 7 days | Indicators | Low | Medium | High |
| Fewer than 200 | New COVID-19 admissions per 100,000 population (7-day total) | <10.0 | 10.0-19.9 | ≥20.0 |
| | Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average) | <10.0% | 10.0-14.9% | ≥15.0% |
| 200 or more | New COVID-19 admissions per 100,000 population (7-day total) | NA | <10.0 | ≥10.0 |
| | Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average) | NA | <10.0% | ≥10.0% |

The COVID-19 community level is determined by the higher of the new admissions and inpatient beds metrics, based on the current level of new cases per 100,000 population in the past 7 days

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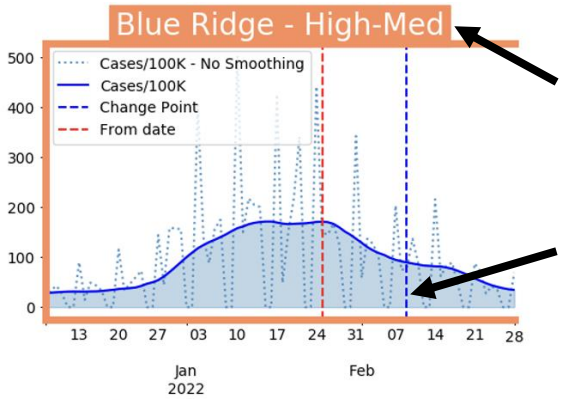
Data from: CDC Data Tracker Portal

# District Trajectories with Community Levels

Community Level (Title Color)
- High
- High-Med
- Med-High
- Medium
- Med-Low
- Low-Med
- Low

Curve shows smoothed case rate (per 100K)
CDC's new Community Level aggregated to district level in label & chart box color
Case Rate curve colored by Trajectory

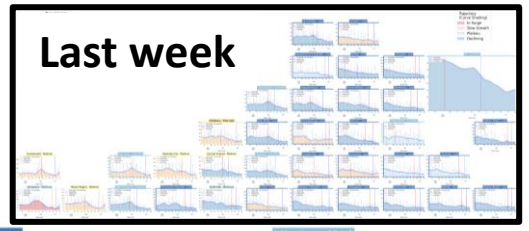
Trajectory (Curve Shading)
- In Surge
- Slow Growth
- Plateau
- Declining




District's Aggregate Community Level

Aggregate level a simple mean of all levels for counties in district

Case rate Trajectory







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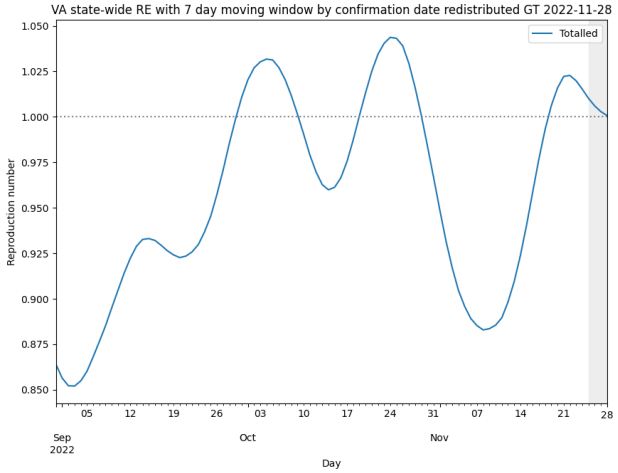
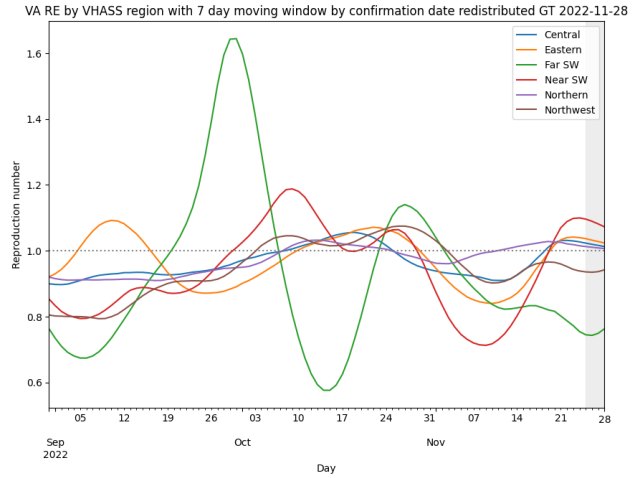
# Estimating Daily Reproductive Number –
## Redistributed gap

### November 28th Estimates

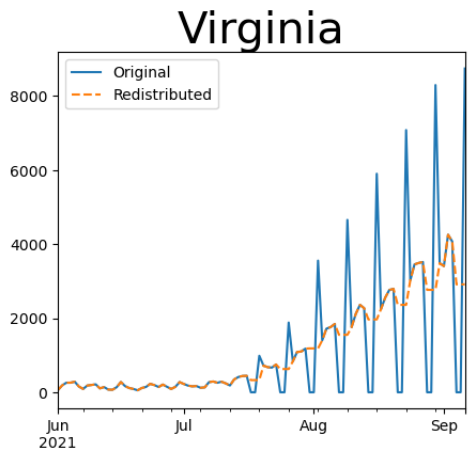
| Region | Date Confirmed $R_e$ | Date Confirmed Diff Last Week |
|---|---|---|
| State-wide | 1.001 | 0.137 |
| Central | 1.013 | 0.189 |
| Eastern | 1.024 | 0.211 |
| Far SW | 0.763 | 0.028 |
| Near SW | 1.073 | 0.329 |
| Northern | 1.007 | 0.046 |
| Northwest | 0.942 | 0.074 |




### Skipping Weekend Reports & holidays biases estimates

Redistributed "big" report day to fill in gaps, and then estimate R from "smoothed" time series




**Methodology**

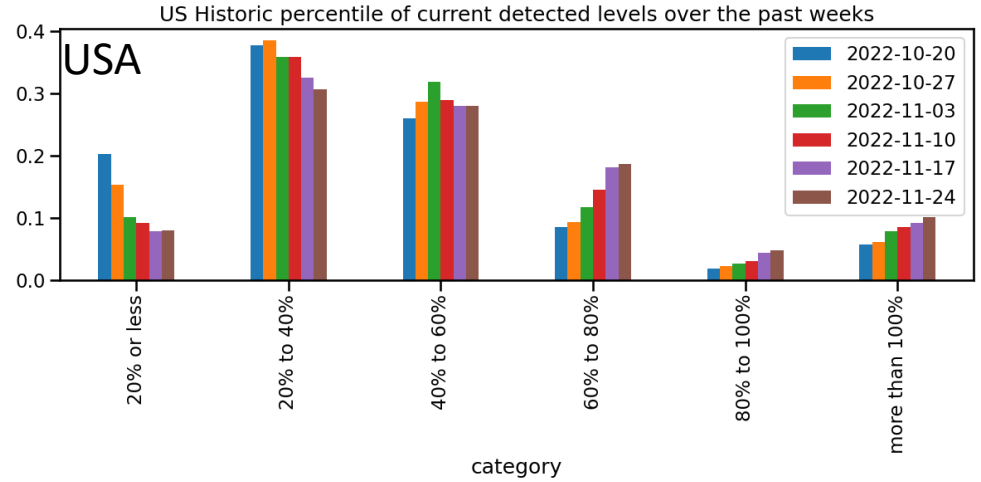
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

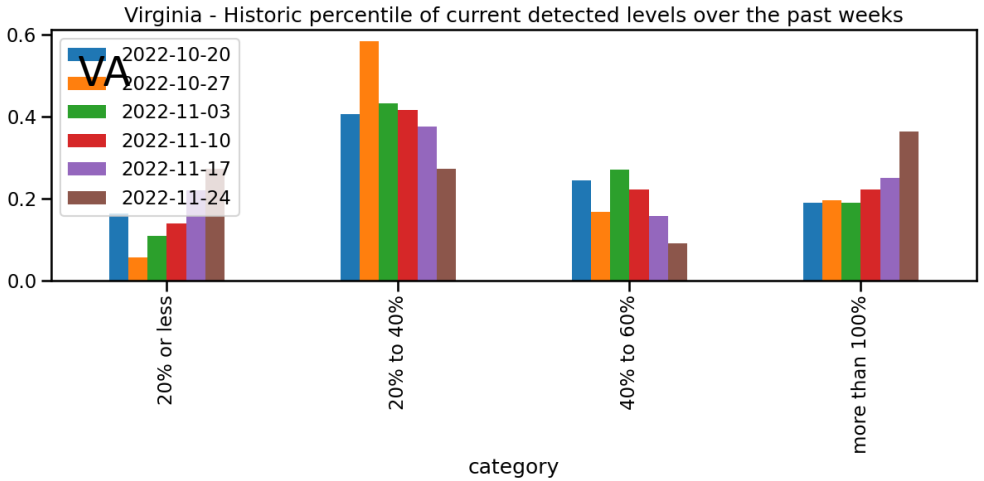

1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

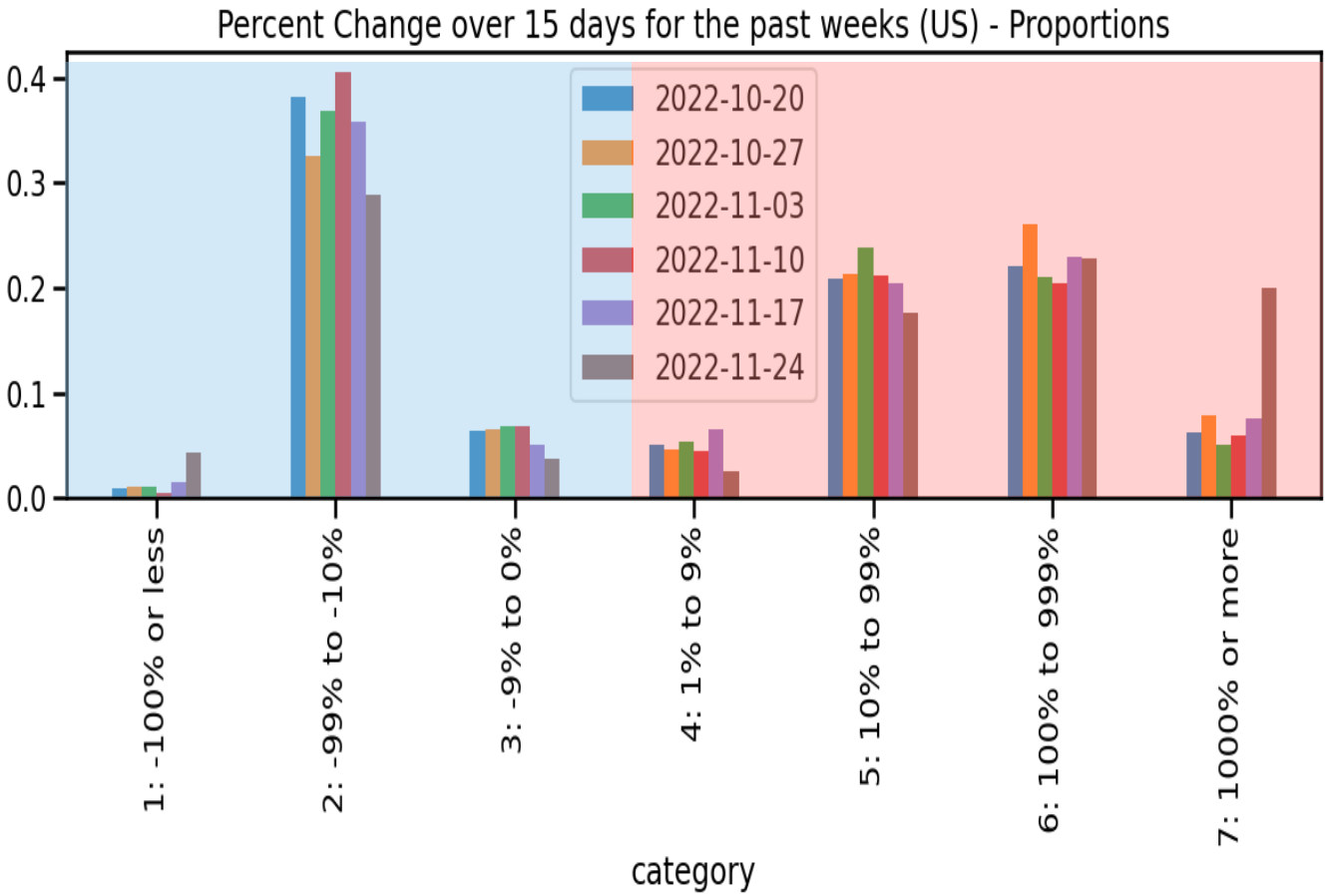
# Wastewater Monitoring

**Wastewater provides a coarse early warning of COVID-19 levels in communities**

- Overall in the US, there is an increase in sites with increased levels of virus compared to 15 days ago
- Growth seen in the category where current virus levels are at or exceeding max of previous historical levels



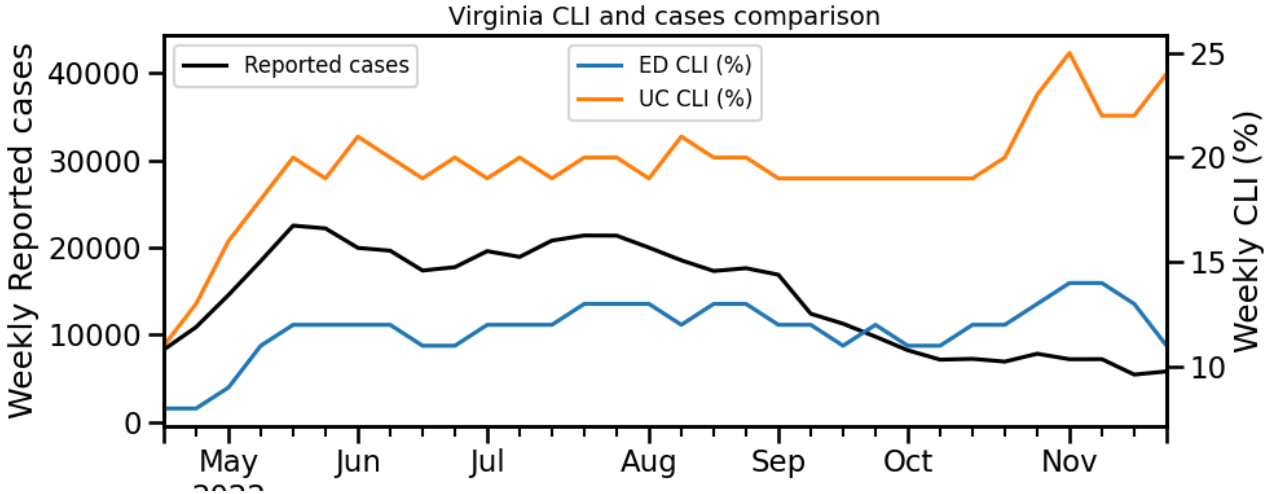



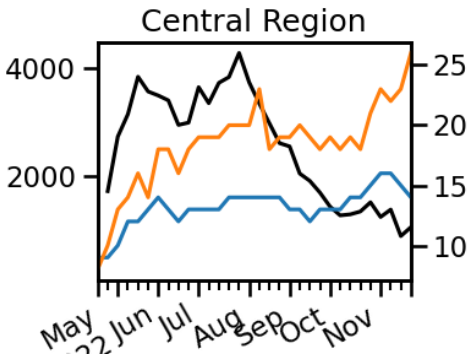

Data Source: CDC Data Tracker

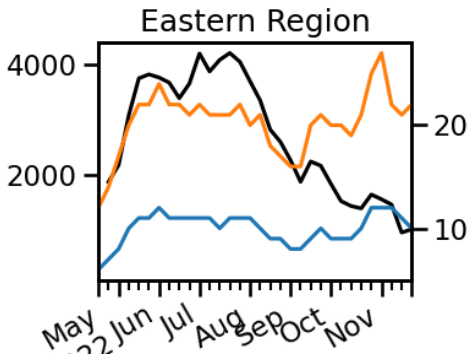
# COVID-like Illness Activity

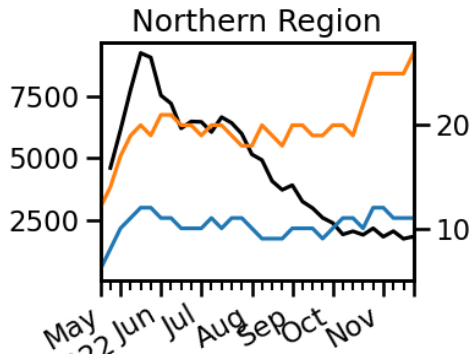
**COVID-like Illness (CLI) gives a measure of COVID transmission in the community**

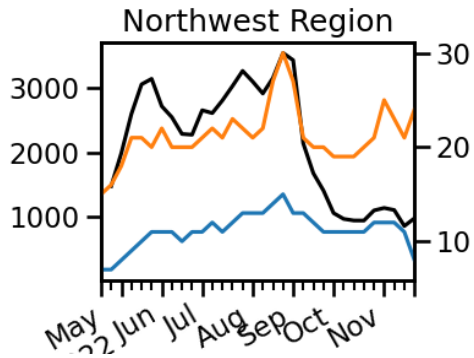
- Emergency Dept (ED) based CLI is more correlated with case reporting
- Urgent Care (UC) is a leading indicator but may be influenced by testing for other URIs
- **After 5 months of plateau, UC CLI remains higher than previous levels statewide**

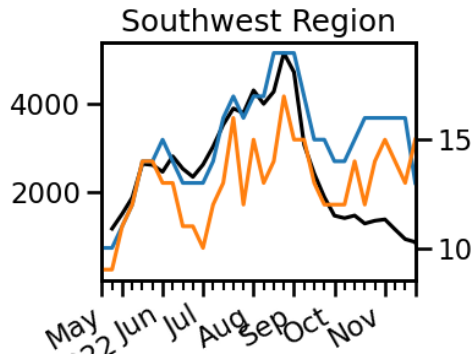


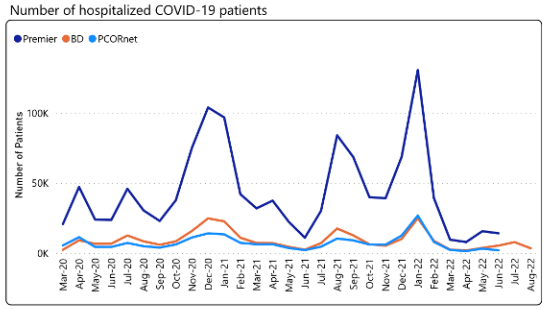



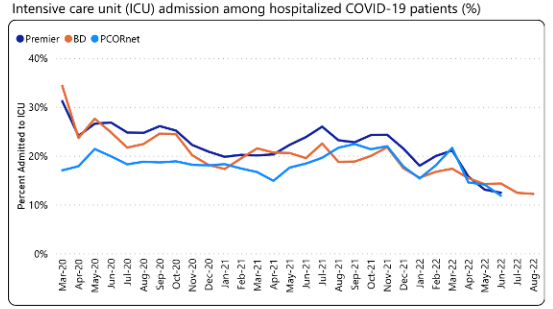
# Hospitalizations and Severe Outcomes

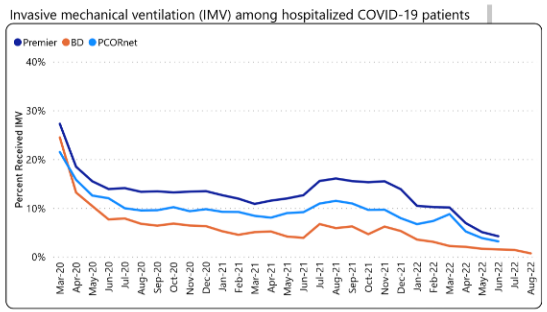
Data Source: [CDC Data Tracker]

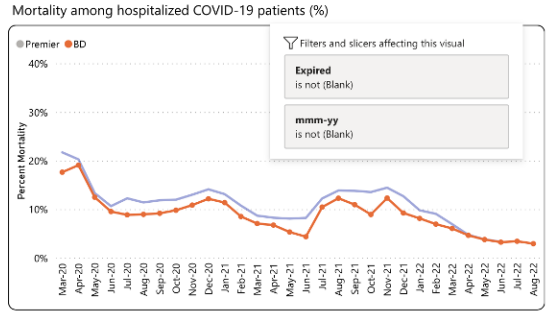
**Proportion of most severe outcomes decreasing among those who are hospitalized**

- ICU has declined from ~20% of hospitalized to 10-15% since initial Omicron wave
- Seen across all age-groups
- Recent rises in these rates have subsided in the past week

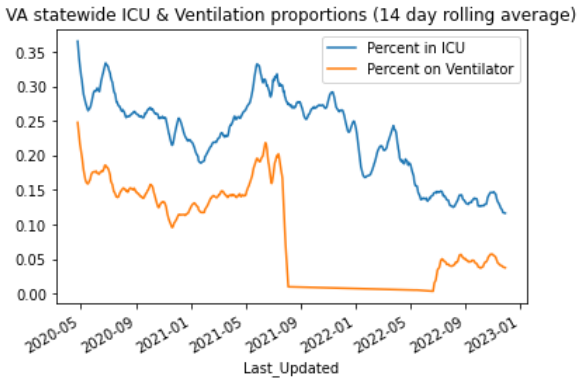


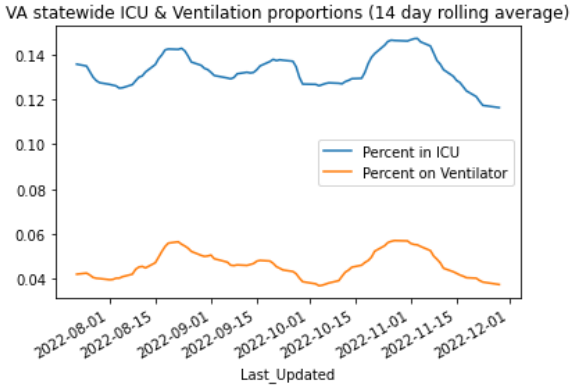



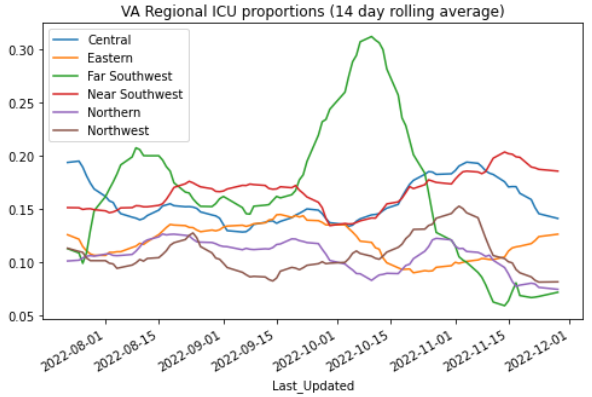

Virginia-wide – full pandemic



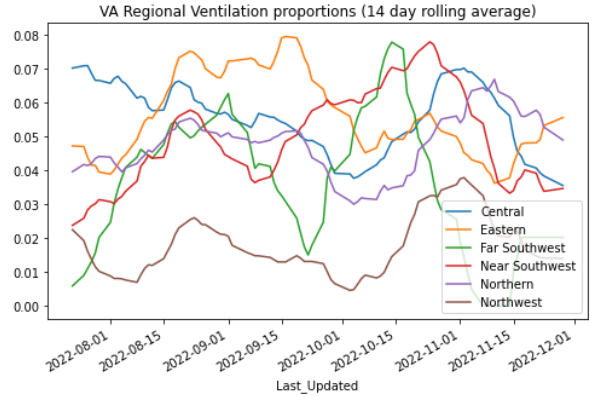

Virginia-wide – recent




Virginia Regional ICU percent




Virginia Regional Ventilation %



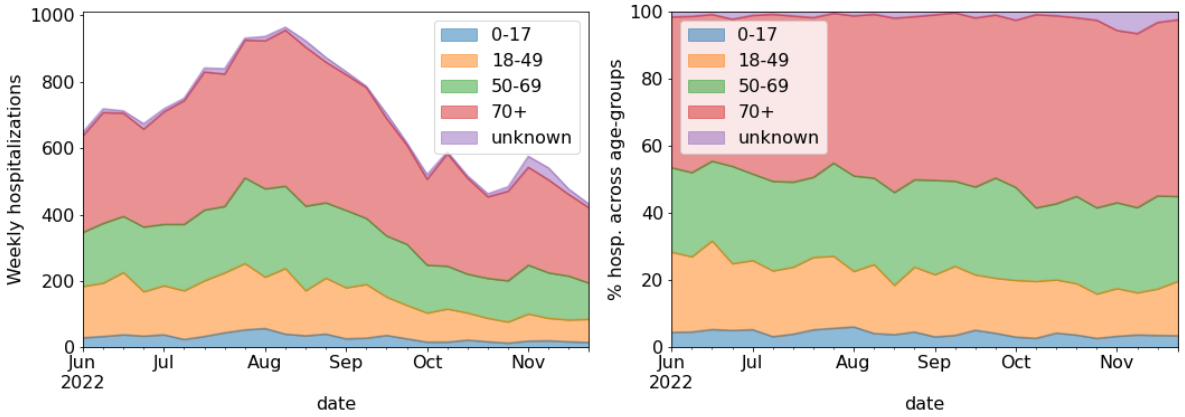
# Hospitalizations in VA by Age

**Age distribution in hospitals relatively stable**

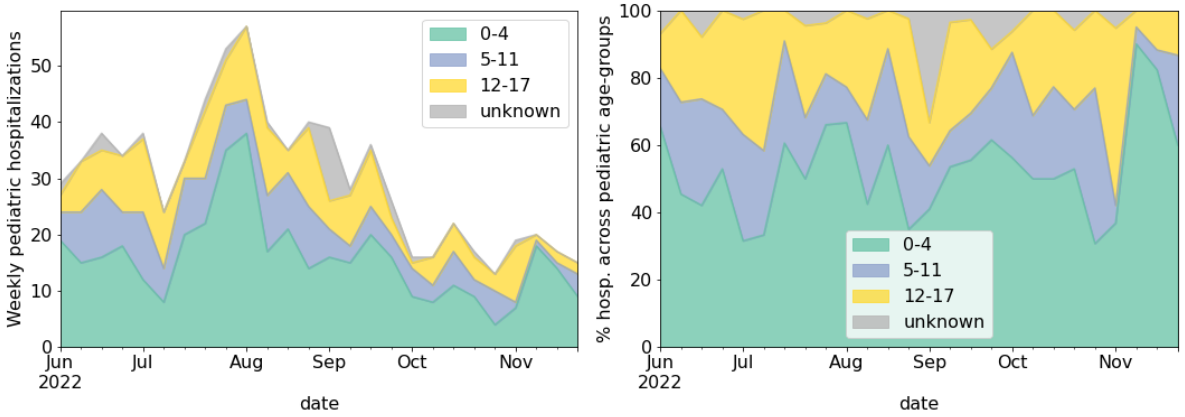
- Recent decline in overall pediatric hospitalizations
- Recent majority among pediatric hospitalizations has been in 0-4-yo

Note: These data are lagged and based on HHS hospital reporting

Virginia Hospitalizations by Age (all ages)




Pediatric Hospitalizations by Age (0-17yo)

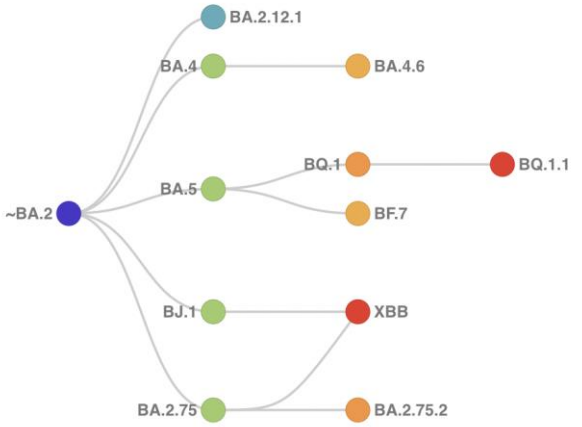



Data Source: Delphi and HHS

# SARS-CoV2 Variants of Concern

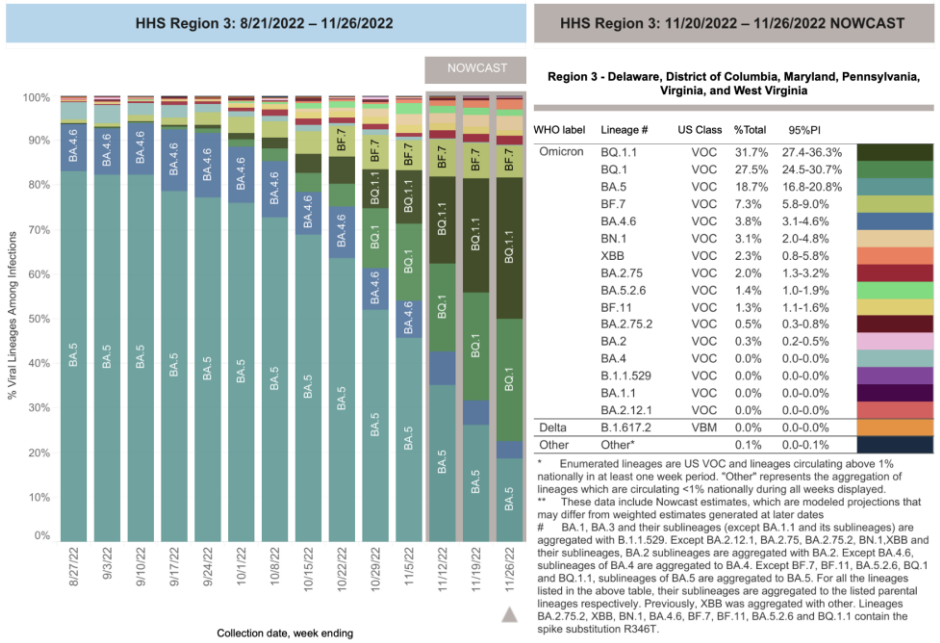
**Emerging variants have potential to continue to alter the future trajectories of pandemic and have implications for future control**

- **Variants have been observed to:** increase transmissibility, increase severity (more hospitalizations and/or deaths), and limit immunity provided by prior infection and vaccinations




## Omicron Updates

- Soup of tracked variants has grown to 82% from 74% last week
- BQ.1.1 remains at 32% with other BQ.1.* variants accounting for another 27%
- BA.2.75.* family variants, including BN.1, have shown more growth recently and now account for nearly a 6% share
- BF.7 and BA.4.6 have been slowly shrinking to 7% and 4%
- BA.5.2.6 and BN.1 are now broken out by CDC nowcast, and account for relatively smaller shares (3% and 4% respectively)
- XBB and subvariants remain a concern and now account for 2%





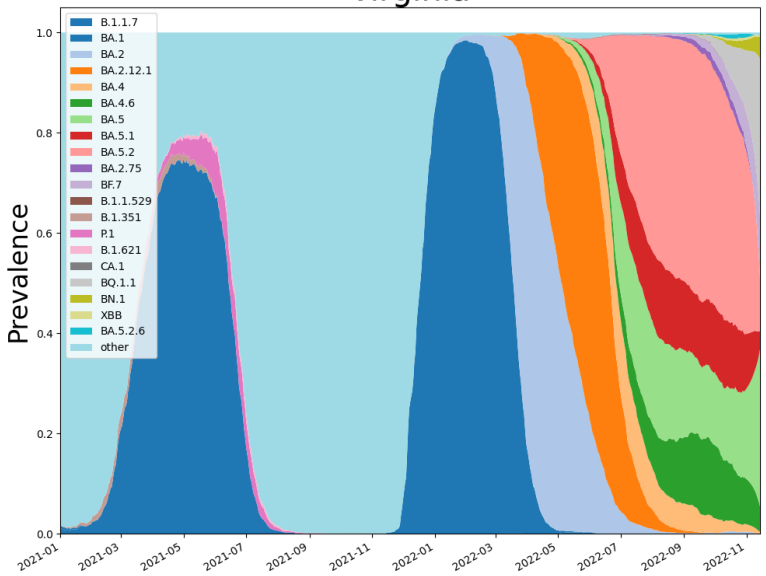

CDC Variant Tracking

# SARS-CoV2 Omicron Sub-Variants

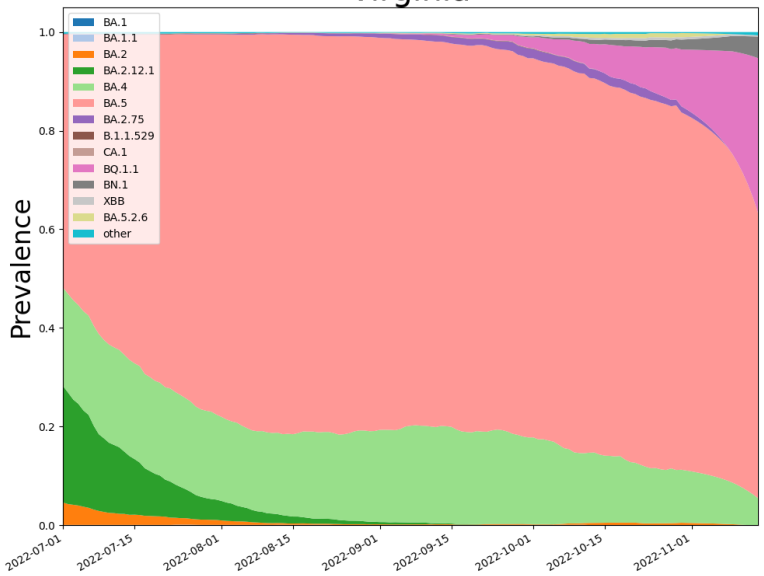
covSPECTRUM
Enabled by data from GISAID

**As detected in whole Genomes in public repositories**

Virginia

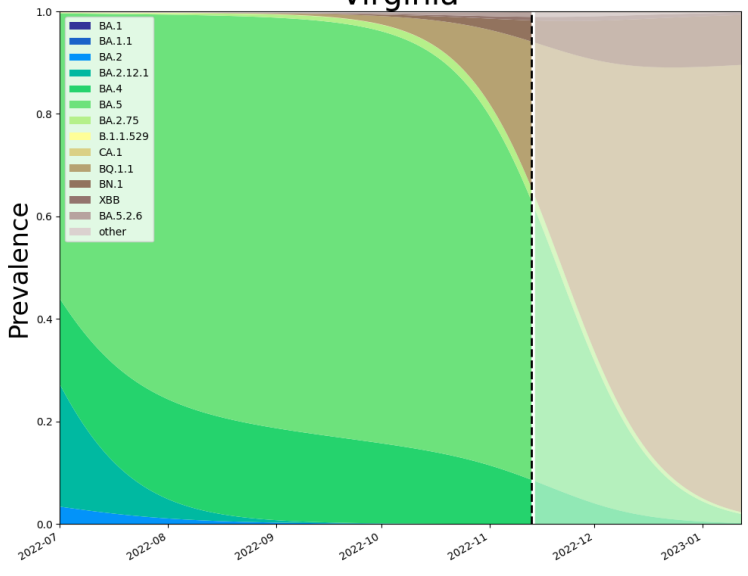



Virginia

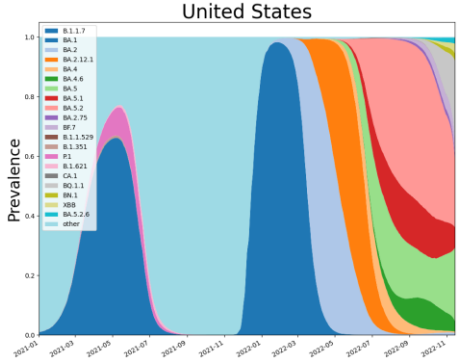



VoC Polynomial Fit Projections

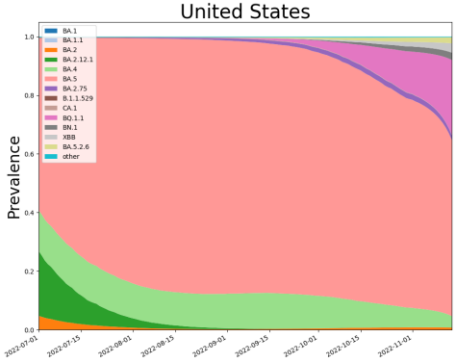
Virginia



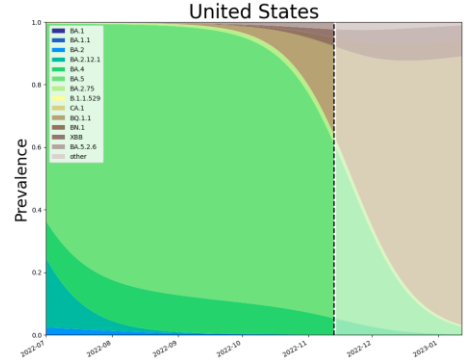

United States




United States




United States




Note: Data lags force projections to start in past. Everything from dotted line forward is a projection.



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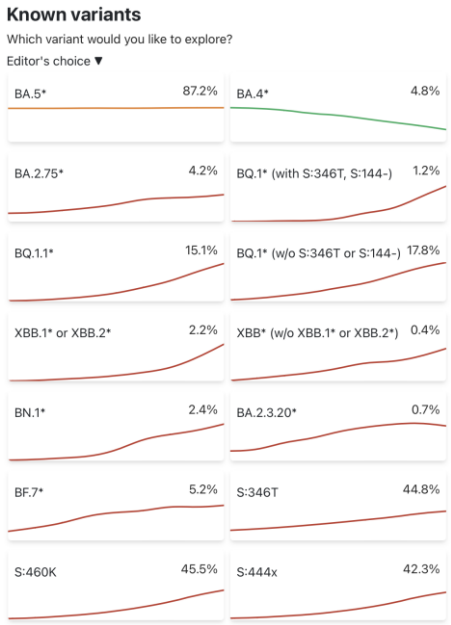
# SARS-CoV2 Omicron Sub-Variants

[COV-spectrum](#)

"Editor's choice"

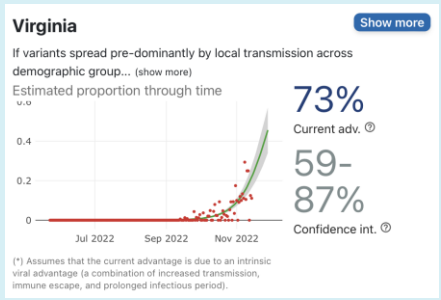
Variants to watch

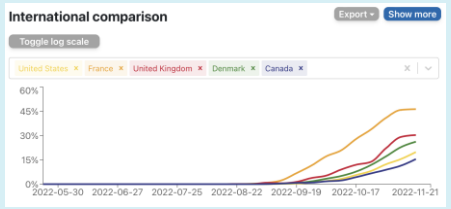


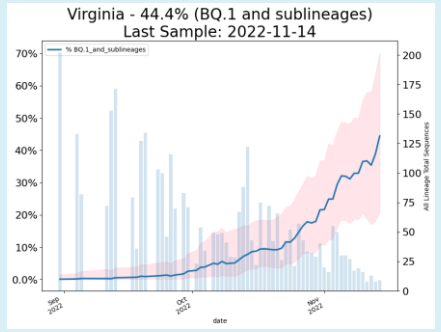

covSPECTRUM

Enabled by data from GISAID

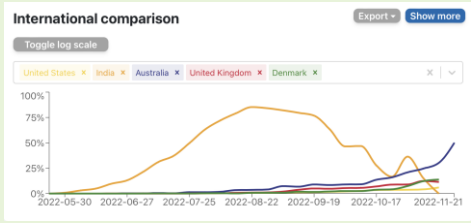
## BQ.1.*

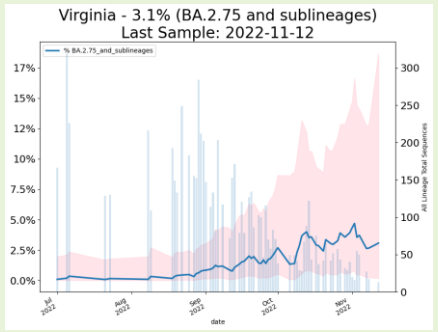


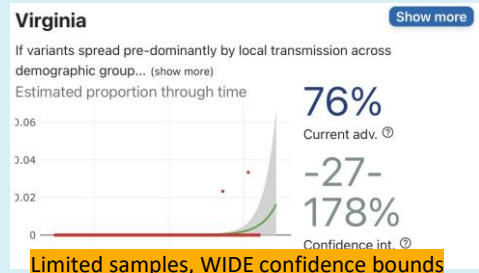




## BA.2.75.*

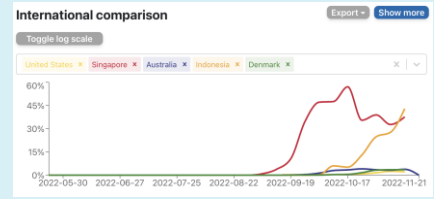



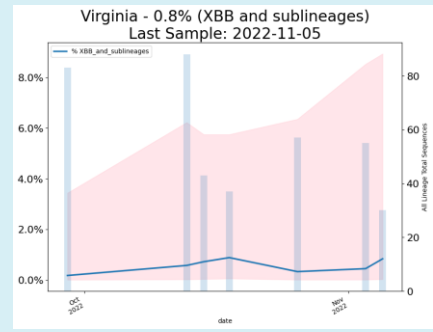




## XBB*



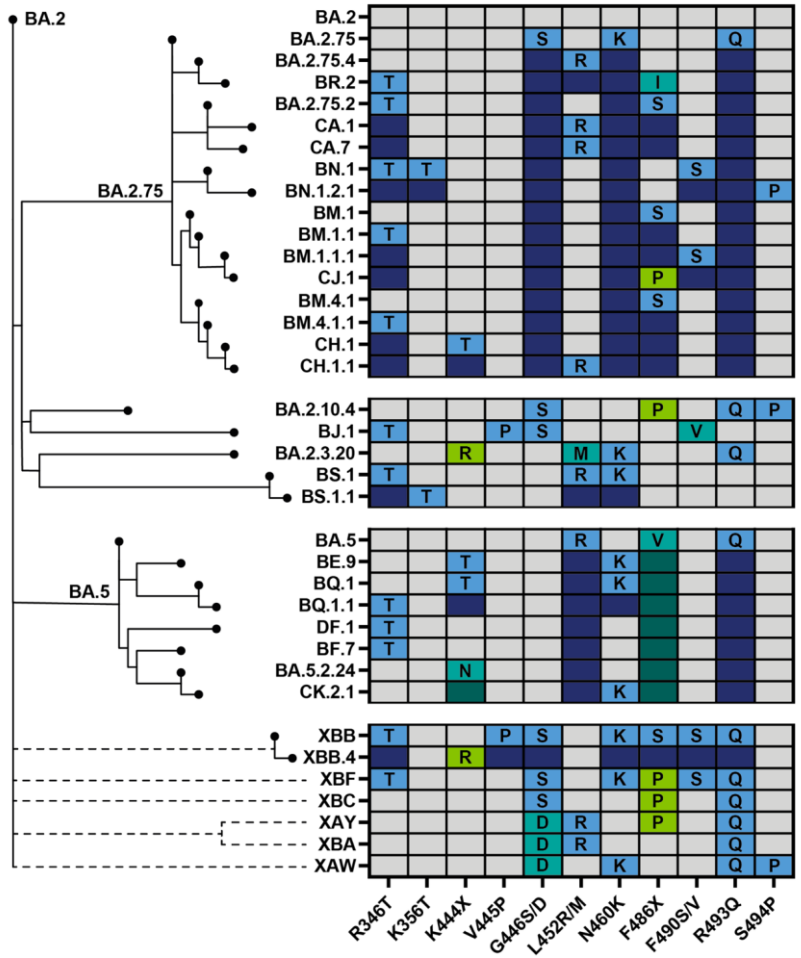

Limited samples, WIDE confidence bounds
Subject to large fluctuations

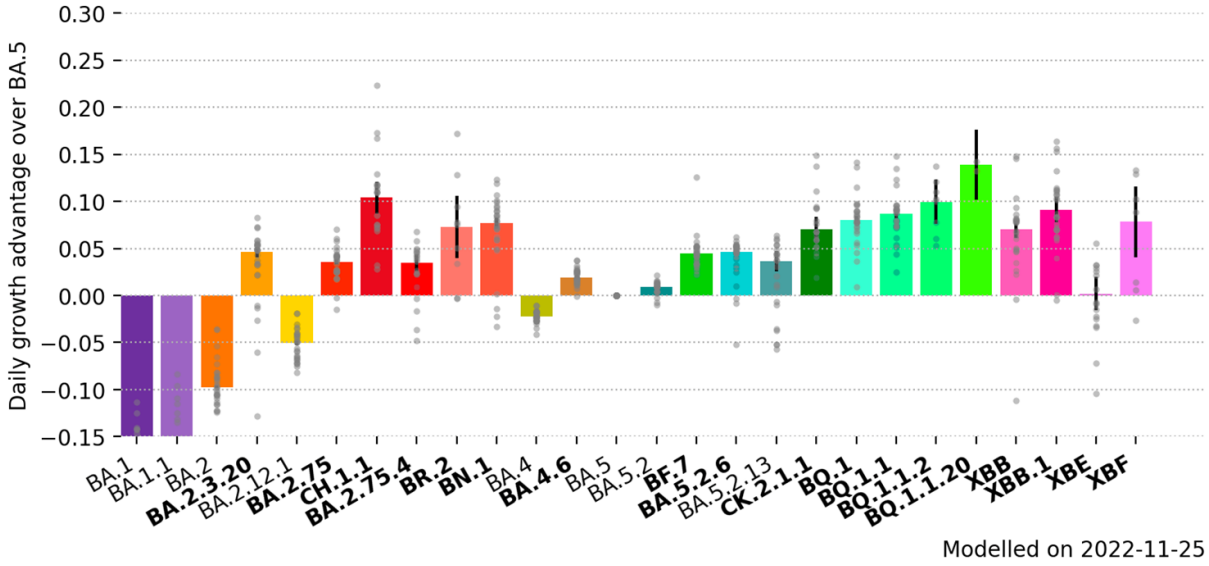


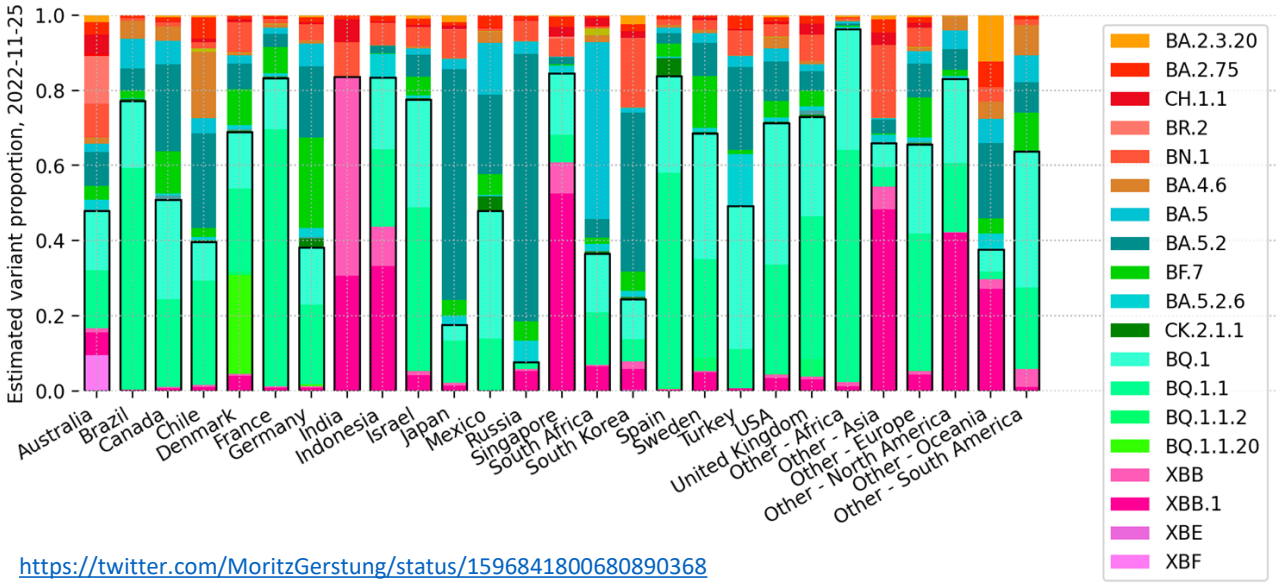



# Pandemic Pubs (Nov 29th, 2022)

1. SARS-CoV-2 surveillance yields both long phylogenetic branch lengths and ladder like mutational patterns, implicating both chronic infection and antigenic drift as likely contributors to fitness, resulting in multiple, potentially antigenically distinct lineages



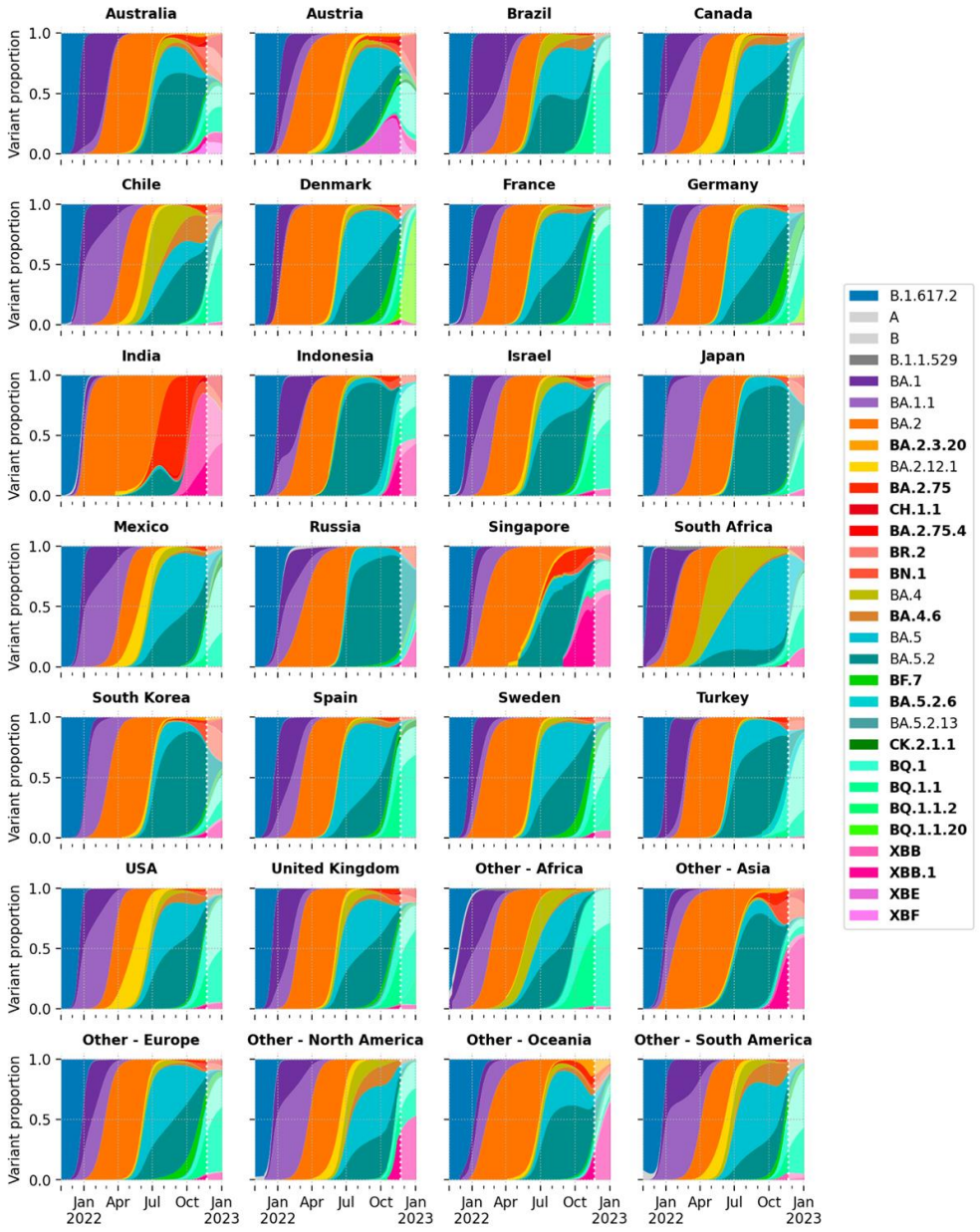



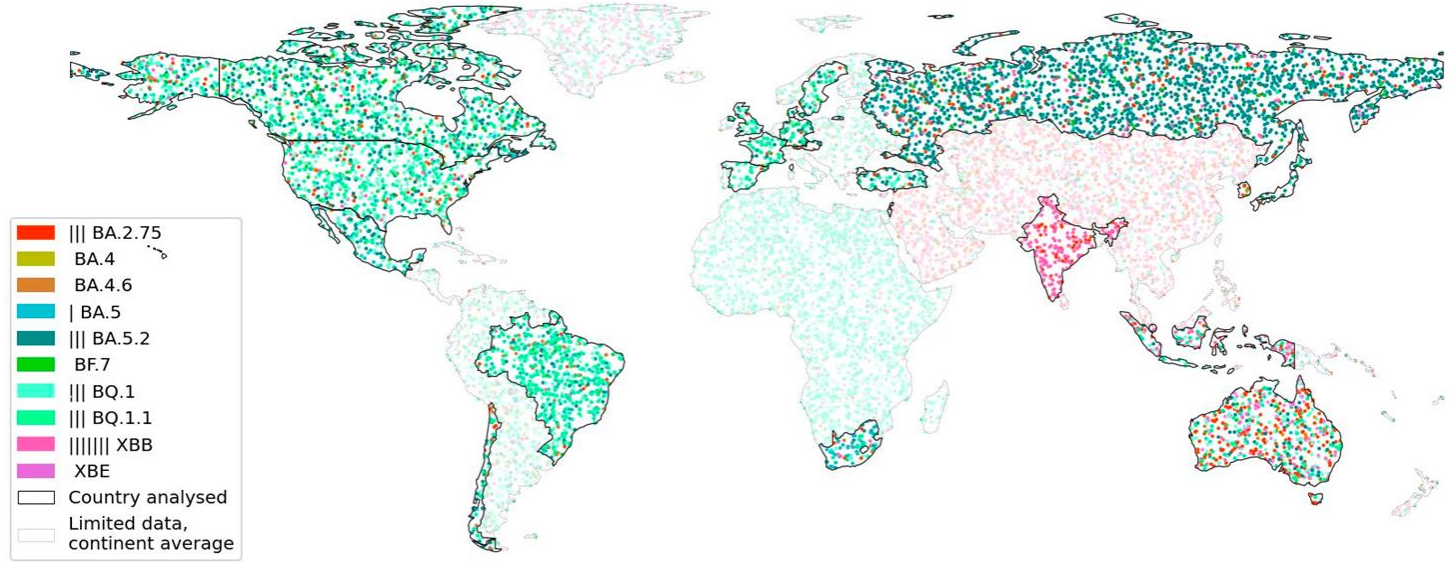

Authors from multiple countries highlight continued evidence that SARS-CoV-2 continues to diversify combinations of antigenically relevant mutations. **Authors raise the possibility that "several lineages could have similar enough growth rates, and enough antigenic distance from one another that they co-circulate, at least until a fitter lineage or variant emerges".**
https://virological.org/t/sars-cov-2-evolution-post-omicron/911#post_1

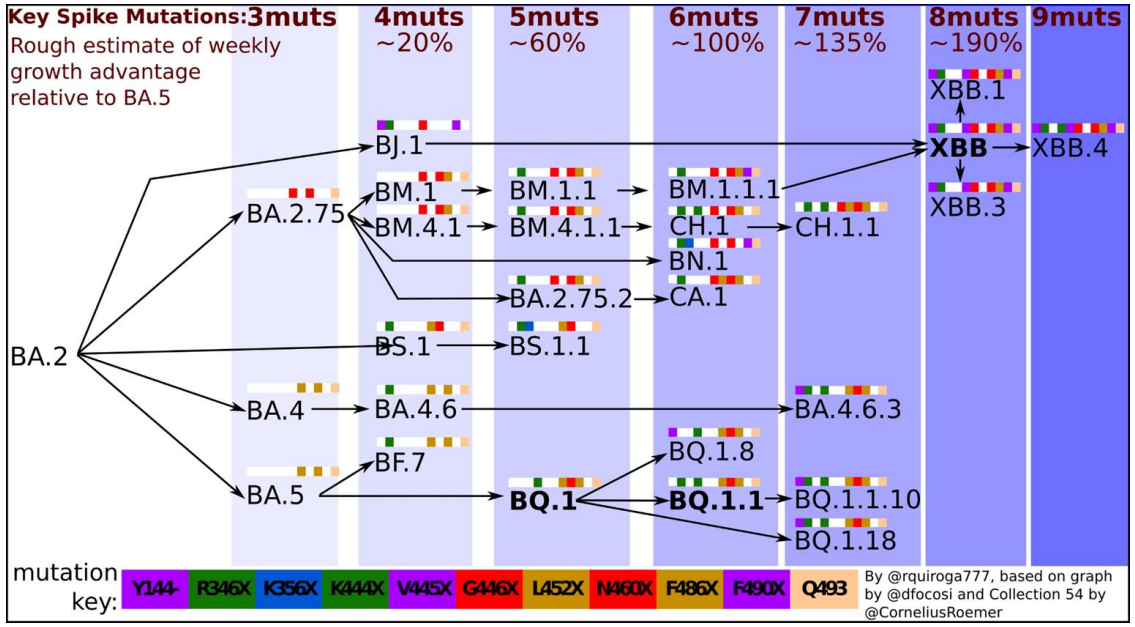
https://twitter.com/MoritzGerstung/status/1596841800680890368

# Pandemic Pubs (Nov 29th, 2022)

## 2. Variants around the world



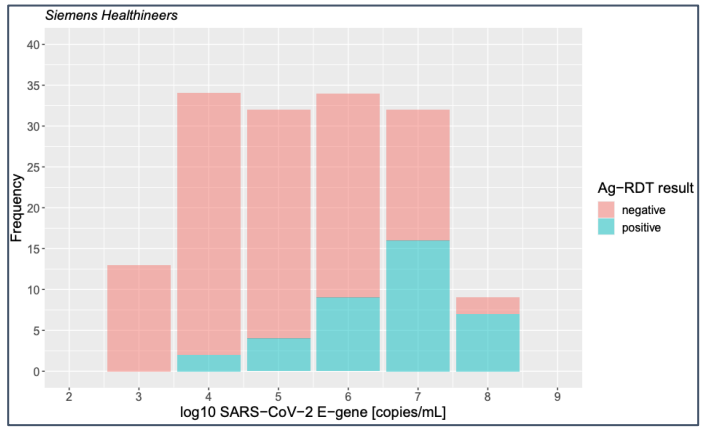



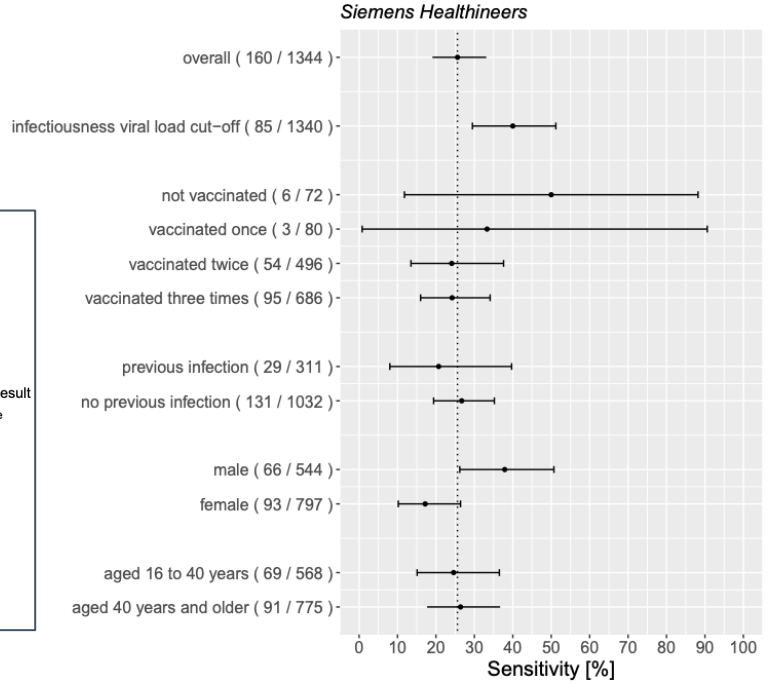

https://twitter.com/MoritzGerstung/status/1596841800680890368
https://twitter.com/PeacockFlu/status/1596492725171675136

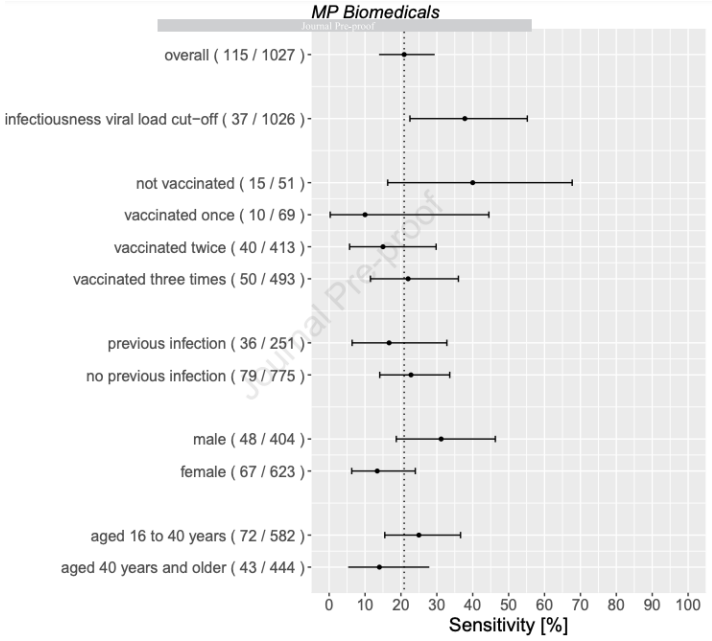
# Pandemic Pubs (Nov 29th, 2022)

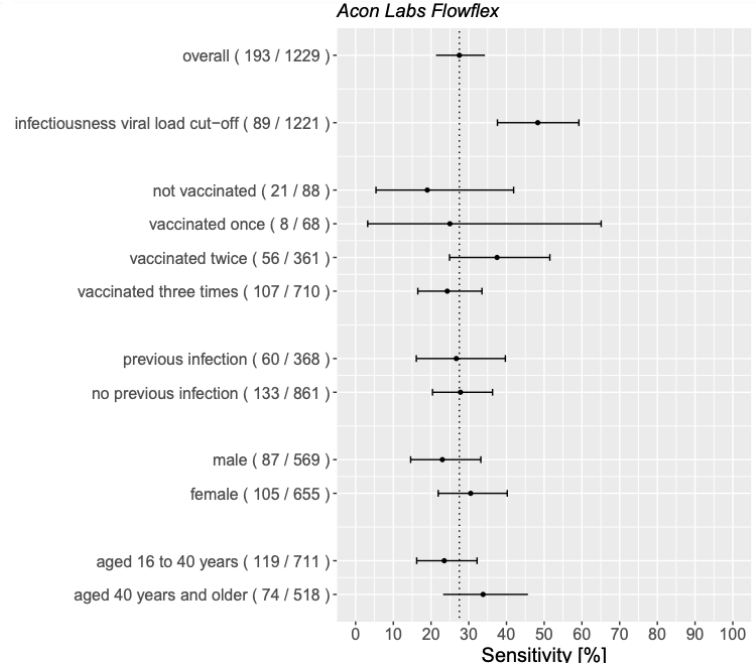
## 3. Netherlands study advocates, provides evidence for, repeated self-testing when asymptomatic testing to protect vulnerable individuals.

| | N | RT-PCR test positivity* [%] | Sensitivity [%] (95%CI) | Specificity [%] (95%CI) | PPV [%] (95%CI) | NPV [%] (95%CI) |
|---|---|---|---|---|---|---|
| **Flowflex** | | | | | | |
| Primary analysis | 1229 | 15.7 | 27.5 (21.3-34.3) | 99.8 (99.3-100) | 96.4 (87.5-99.6) | 88.1 (86.1-89.9) |
| Secondary (stratified) analyses: | | | | | | |
| Viral load cut-off¶ | 1221 | 7.3 | 48.3 (37.6-59.2) | 99.2 (98.5-99.6) | 82.7 (69.7-91.8) | 96.1 (94.8-97.1) |
| Vaccinated (at least once): | | | | | | |
| Yes | 1140 | 15.1 | 28.5 (21.9-35.9) | 99.8 (99.3-100) | 96.1 (86.5-99.5) | 88.7 (86.7-90.5) |
| No | 88 | 23.9 | 19.0 (5.4-41.9) | 100 (94.6-100) | 100 (39.8-100) | 79.8 (69.6-87.7) |
| Previous SARS-CoV-2 infection: | | | | | | |
| Yes | 368 | 16.3 | 26.7 (16.1-39.7) | 99.7 (98.2-100) | 94.1 (71.3-99.9) | 87.5 (83.5-90.7) |
| No | 861 | 15.4 | 27.8 (20.4-36.3) | 99.9 (99.2-100) | 97.4 (86.2-99.9) | 88.3 (85.9-90.4) |
| Sex: | | | | | | |
| Female | 655 | 16.0 | 30.5 (21.9-40.2) | 99.8 (99.0-100) | 97.0 (84.2-99.9) | 88.3 (85.5-90.7) |
| Male | 569 | 15.3 | 23.0 (14.6-33.2) | 99.8 (98.8-100) | 95.2 (76.2-99.9) | 87.8 (84.7-90.4) |
| Age [years]: | | | | | | |
| 16-40 | 711 | 16.7 | 23.5 (16.2-32.2) | 99.8 (99.1-100) | 96.6 (82.2-99.9) | 86.7 (83.9-89.1) |
| >40 | 518 | 14.3 | 33.8 (23.2-45.7) | 99.8 (98.8-100) | 96.2 (80.4-99.9) | 90.0 (87.0-92.5) |
| **MPBio** | | | | | | |
| Primary analysis | 1027 | 11.2 | 20.9 (13.9-29.4) | 99.8 (99.2-100) | 92.3 (74.9-99.1) | 90.9 (89.0-92.6) |
| Secondary (stratified) analyses: | | | | | | |
| Viral load cut-off¶ | 1026 | 3.6 | 37.8 (22.5-55.2) | 98.8 (97.9-99.4) | 53.8 (33.4-73.4) | 97.7 (96.6-98.5) |
| Vaccinated (at least one): | | | | | | |
| Yes | 975 | 10.3 | 18.0 (11.0-26.9) | 99.8 (99.2-100) | 90.0 (68.3-98.8) | 91.4 (89.5-93.1) |
| No | 51 | 29.4 | 40.0 (16.3-67.7) | 100 (90.3-100) | 100 (54.1-100) | 80.0 (65.4-90.4) |
| Previous SARS-CoV-2 infection: | | | | | | |
| Yes | 251 | 14.3 | 16.7 (6.4-32.8) | 100 (98.3-100) | 100 (54.1-100) | 87.8 (83.0-91.6) |
| No | 775 | 10.2 | 22.8 (14.1-33.6) | 99.7 (99.0-100) | 90.0 (68.3-98.8) | 91.9 (89.7-93.8) |
| Sex: | | | | | | |
| Female | 623 | 10.8 | 13.4 (6.3-24.0) | 99.8 (99.0-100) | 90.0 (55.5-99.7) | 90.5 (87.9-92.7) |
| Male | 404 | 11.9 | 31.2 (18.7-46.3) | 99.7 (98.4-100) | 93.8 (69.8-99.8) | 91.5 (88.3-94.1) |
| Age [years]: | | | | | | |
| 16-40 | 582 | 12.4 | 25.0 (15.5-36.6) | 99.8 (98.9-100) | 94.7 (74.0-99.9) | 90.4 (87.7-92.7) |
| >40 | 444 | 9.7 | 14.0 (5.3-27.9) | 99.8 (98.6-100) | 85.7 (42.1-99.6) | 91.5 (88.5-94.0) |
| **Clinitest** | | | | | | |
| Primary analysis | 1344 | 11.9 | 25.6 (19.1-33.1) | 99.9 (99.5-100) | 97.6 (87.4-99.9) | 90.9 (89.2-92.4) |
| Secondary (stratified) analyses: | | | | | | |
| Viral load cut-off¶ | 1340 | 6.3 | 40.0 (29.5-51.2) | 99.5 (99.0-99.8) | 85.0 (70.2-94.3) | 96.1 (94.9-97.1) |
| Vaccinated (at least one): | | | | | | |
| Yes | 1271 | 12.0 | 24.8 (18.2-32.5) | 99.9 (99.5-100) | 97.4 (86.5-99.9) | 90.7 (88.9-92.2) |
| No | 72 | 8.3 | 50.0 (11.8-88.2) | 100 (94.6-100) | 100 (29.2-100) | 95.7 (87.8-99.1) |
| Previous SARS-CoV-2 infection: | | | | | | |
| Yes | 311 | 9.3 | 20.7 (8.0-39.7) | 99.6 (98.0-100) | 85.7 (42.1-99.6) | 92.4 (88.9-95.1) |
| No | 1032 | 12.7 | 26.7 (19.4-35.2) | 100 (99.6-100) | 100 (90.0-100) | 90.4 (88.4-92.1) |
| Sex: | | | | | | |
| Female | 797 | 11.7 | 17.2 (10.2-26.4) | 100 (99.5-100) | 100 (79.4-100) | 90.1 (87.8-92.1) |
| Male | 544 | 12.1 | 37.9 (26.2-50.7) | 99.8 (98.8-100) | 96.2 (80.4-99.9) | 92.1 (89.4-94.3) |
| Age [years]: | | | | | | |
| 16-40 | 568 | 12.1 | 24.6 (15.1-36.5) | 99.8 (98.9-100) | 94.4 (72.7-99.9) | 90.5 (87.8-92.9) |
| >40 | 775 | 11.7 | 26.4 (17.7-36.7) | 100 (99.5-100) | 100 (85.8-100) | 91.1 (88.8-93.0) |



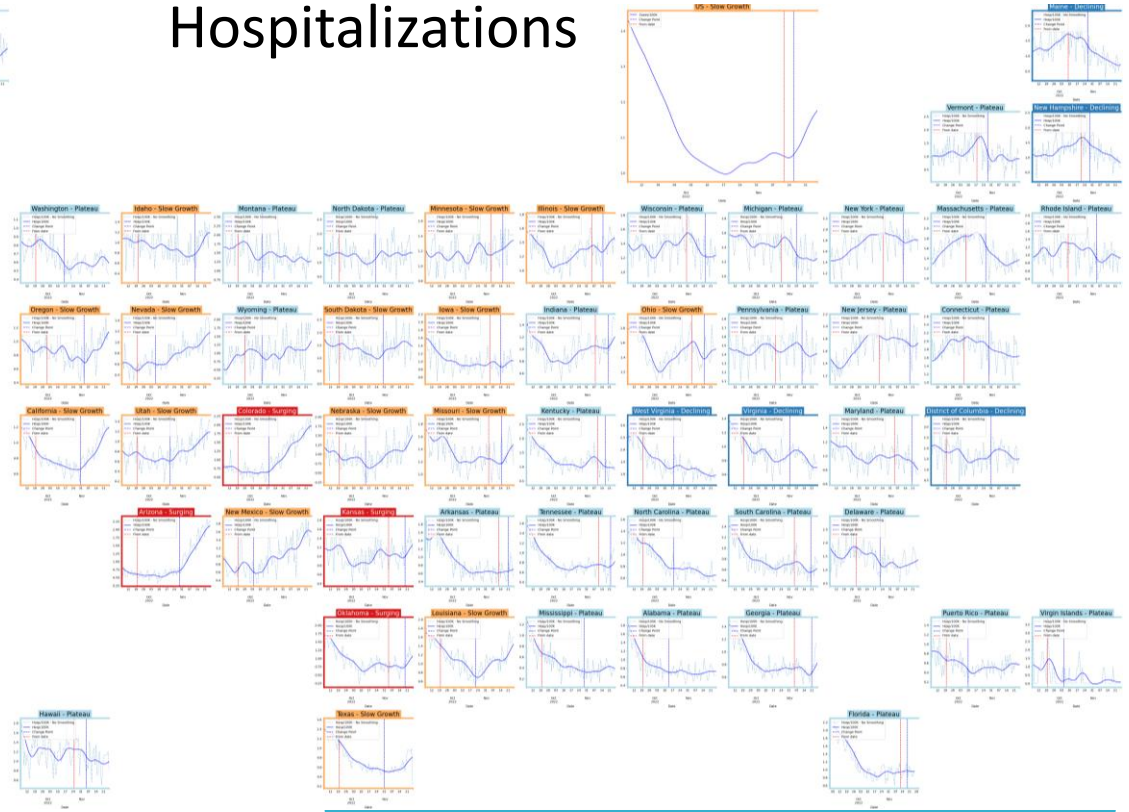

Researchers in the Netherlands performed a cross-sectional study in the Omicron period in three public health service covid-19 test sites in the **Netherlands including 3,600 asymptomatic individuals presenting for SARS-CoV-2 testing for any reason except confirmatory testing after a positive self-test. Sensitivities of three commonly used SARS-CoV-2 Ag-RDTs when used as self-tests in asymptomatic individuals in the Omicron period were very low**. Authors state "self-testing has limited value for asymptomatic individuals wishing to protect vulnerable persons and may even lead to a false sense of security." Applying a viral load cut-off (≥5.2 log10 SARS-CoV-2 E-gene copies/mL), sensitivities increased to 48.3% (37.6 to 59.2%), 37.8% (22.5 to 55.2%), and 40.0% (29.5 to 51.2%), Acon Flowflex (Flowflex), MP Biomedicals (MPBio), and Siemens-Healthineers Clinitest (Clinitest) respectively. Cut-off established above which 95% of people with a positive RT-PCR test result had a positive virus culture in that previous study

https://www.clinicalmicrobiologyandinfection.com/article/S1198-743X(22)00570-5/fulltext#gr2

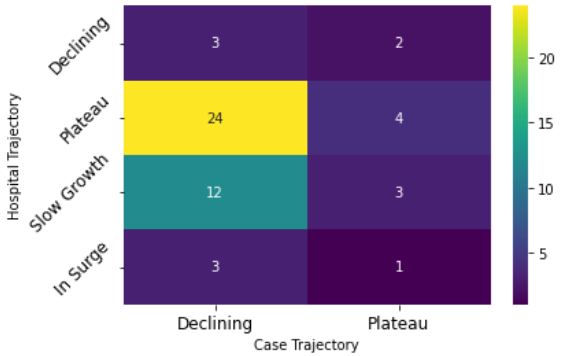
# United States Cases & Hospitalizations

## Cases


## Hospitalizations



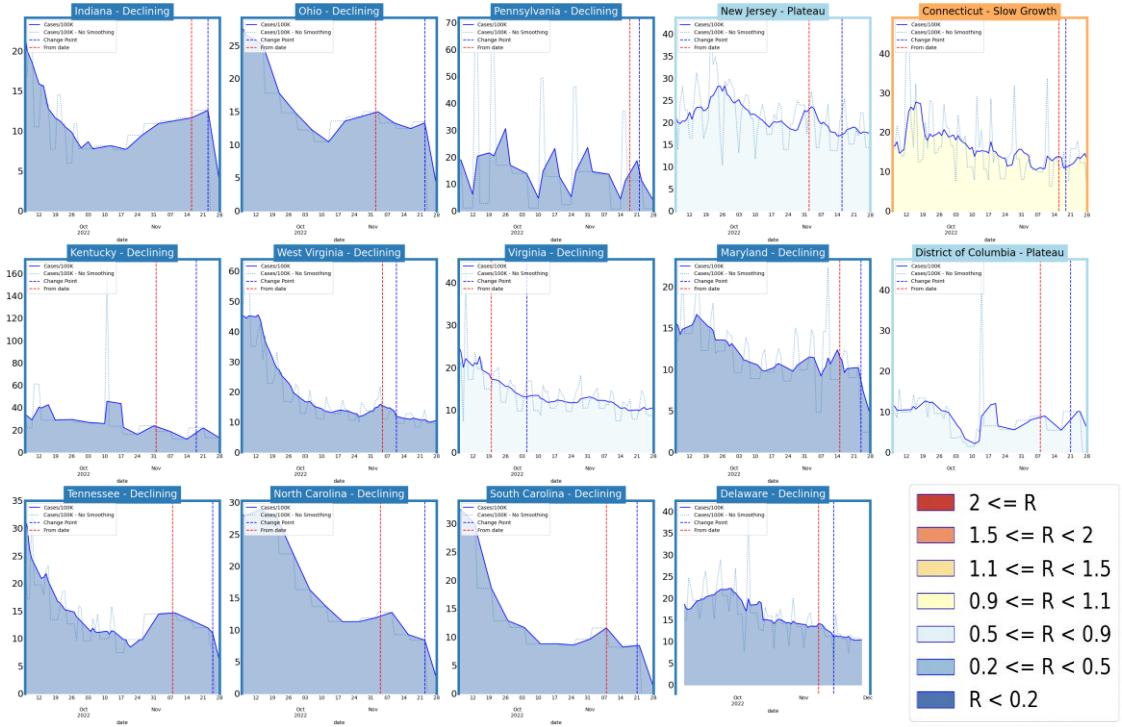
| Status | Number of States | |
|---|---|---|
| | Current Week | Last Week |
| Declining | 42 | (40) |
| Plateau | 11 | (10) |
| Slow Growth | 1 | (2) |
| In Surge | 0 | (2) |



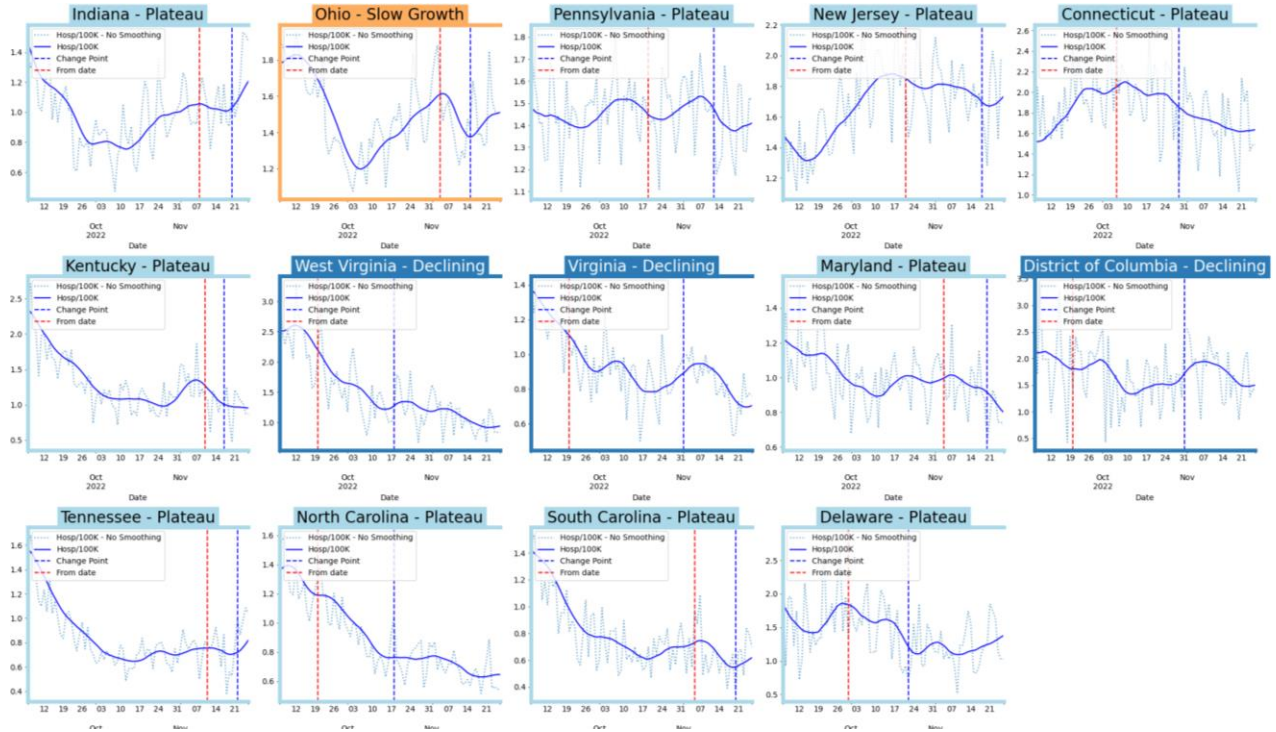

| Status | Number of States | |
|---|---|---|
| | Current Week | Last Week |
| Declining | 5 | (4) |
| Plateau | 29 | (36) |
| Slow Growth | 15 | (11) |
| In Surge | 4 | (2) |

# Virginia and Her Neighbors

## Cases

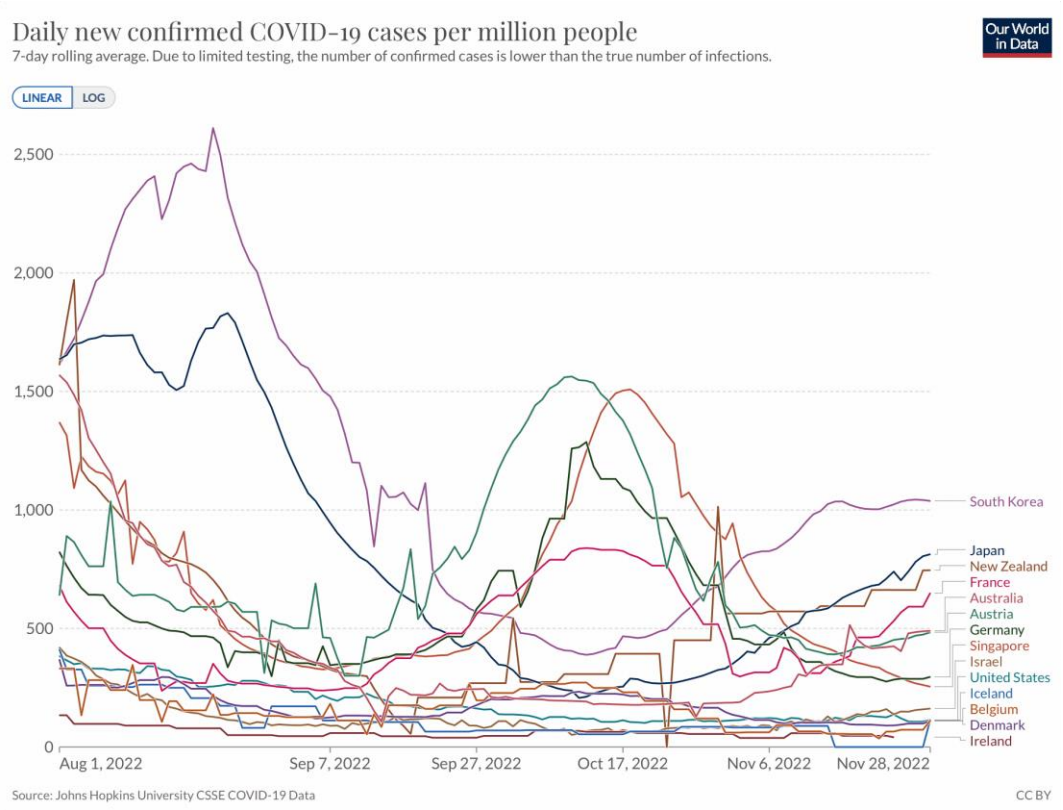



## Hospitalizations

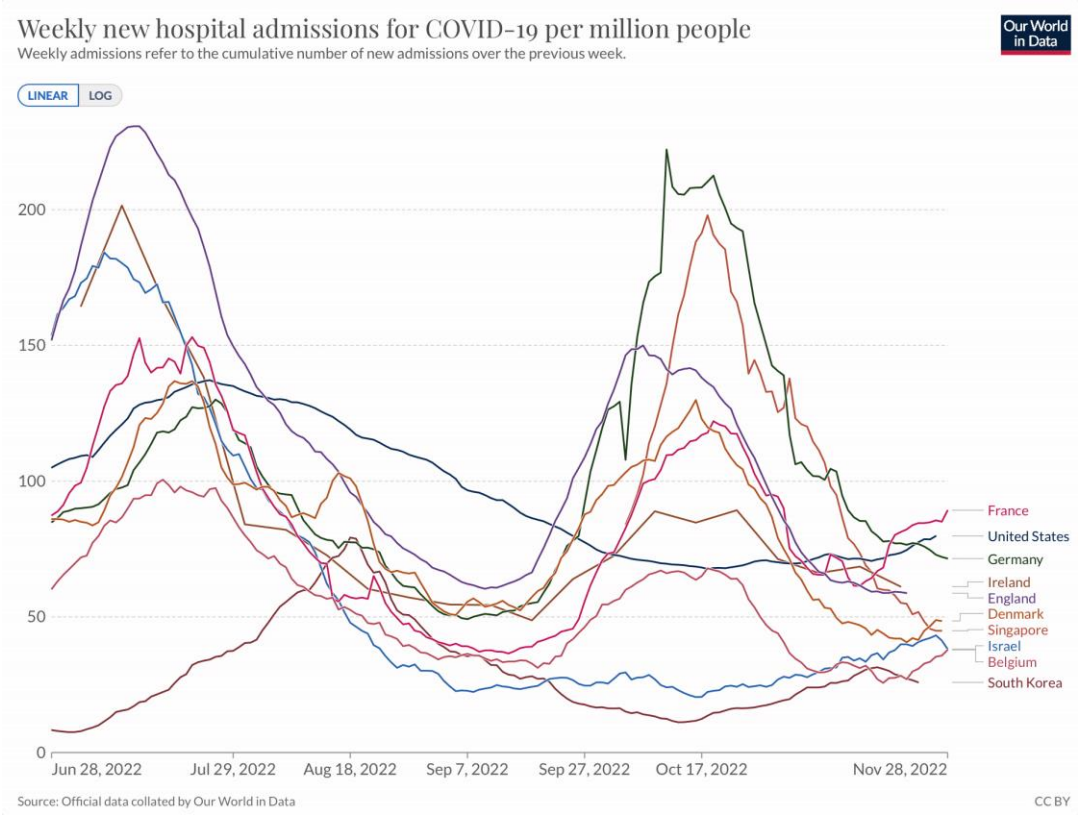


# Around the World – Various trajectories

## Confirmed cases




## Hospitalizations




Our World in Data [Our World in Data]

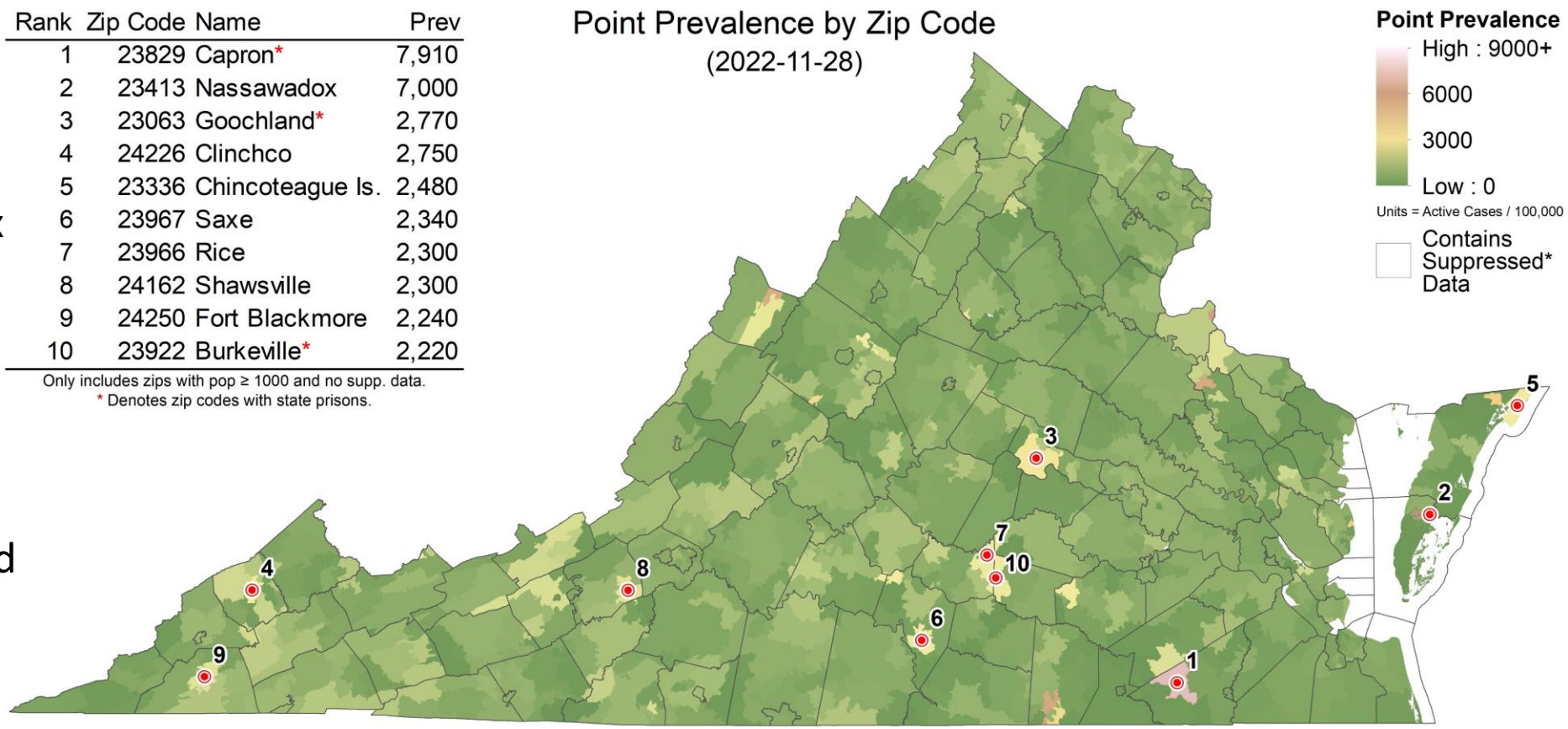
# Zip code level weekly Case Rate (per 100K)

**Case Rates in the last week by zip code**

- Statewide rates remain quite low. We may need to adjust our color ramp for next week.
- Capron and Nassawadox are outliers with more than double any other zip's point prevalence.
- Three prisons appear in this week's top 10.
- Some counts are low and suppressed to protect anonymity. Those are shown with a dark red outline.

| Rank | Zip Code | Name | Prev |
|---|---|---|---|
| 1 | 23829 | Capron* | 7,910 |
| 2 | 23413 | Nassawadox | 7,000 |
| 3 | 23063 | Goochland* | 2,770 |
| 4 | 24226 | Clinchco | 2,750 |
| 5 | 23336 | Chincoteague Is. | 2,480 |
| 6 | 23967 | Saxe | 2,340 |
| 7 | 23966 | Rice | 2,300 |
| 8 | 24162 | Shawsville | 2,300 |
| 9 | 24250 | Fort Blackmore | 2,240 |
| 10 | 23922 | Burkeville* | 2,220 |

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.




Based on Spatial Empirical Bayes smoothed point prevalence, with an 8:1 ascertainment ratio, for week ending 2022-11-28.

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# Risk of Exposure by Group Size and HCW prevalence

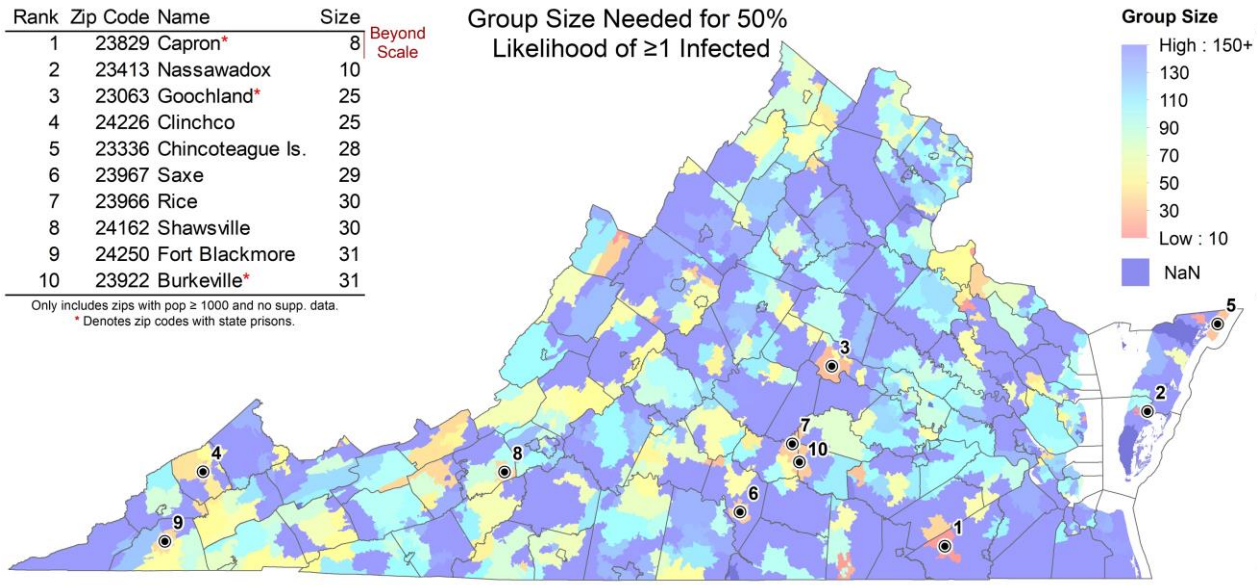
**Case Prevalence in the last week by zip code used to calculate risk of encountering someone infected in a gathering of randomly selected people**

- **Group Size**: Assumes **8 undetected infections** per confirmed case (ascertainment rate from recent seroprevalence survey) and shows minimum size of a group with a 50% chance an individual is infected by zip code (e.g., in a group of 8 in Capron, there is a 50% chance someone will be infected).
- **HCW ratio**: Case rate among health care workers (HCW) in the last week using patient facing health care workers as the denominator / population's case prevalence. Madison Co. is no longer in the top 10.

| Rank | Zip Code | Name | Size |
|---|---|---|---|
| 1 | 23829 | Capron* | 8 |
| 2 | 23413 | Nassawadox | 10 |
| 3 | 23063 | Goochland* | 25 |
| 4 | 24226 | Clinchco | 25 |
| 5 | 23336 | Chincoteague Is. | 28 |
| 6 | 23967 | Saxe | 29 |
| 7 | 23966 | Rice | 30 |
| 8 | 24162 | Shawsville | 30 |
| 9 | 24250 | Fort Blackmore | 31 |
| 10 | 23922 | Burkeville* | 31 |

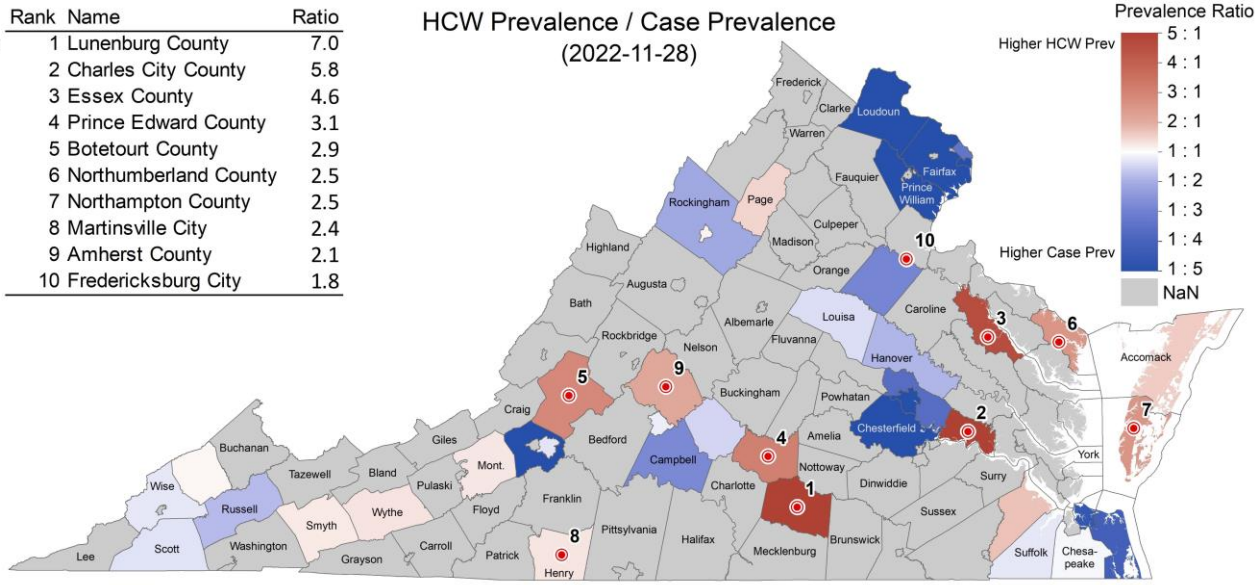
Beyond Scale

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.




Based on Spatial Empirical Bayes smoothed point prevalence, with an 8:1 ascertainment ratio, for week ending 2022-11-28.

| Rank | Name | Ratio |
|---|---|---|
| 1 | Lunenburg County | 7.0 |
| 2 | Charles City County | 5.8 |
| 3 | Essex County | 4.6 |
| 4 | Prince Edward County | 3.1 |
| 5 | Botetourt County | 2.9 |
| 6 | Northumberland County | 2.5 |
| 7 | Northampton County | 2.5 |
| 8 | Martinsville City | 2.4 |
| 9 | Amherst County | 2.1 |
| 10 | Fredericksburg City | 1.8 |




Note: This assumes that the ascertainment rate of healthcare workers is double that of the public.

# Current Hot-Spots

**Case rates that are significantly different from neighboring areas or model projections**

- **Spatial**: Getis-Ord Gi* based hot spots compare clusters of zip codes with weekly case prevalence higher than nearby zip codes to identify larger areas with statistically significant deviations
- **Temporal**: The weekly case rate (per 100K) projected last week compared to observed by county, which highlights temporal fluctuations that differ from the model's projections.
- Capron and Nassawadox lead the spatial hotspots. Temporal hotspots are primarily found in central Virginia and along the coast. Model forecasts tracked cases very well, and there was no residual autocorrelation.

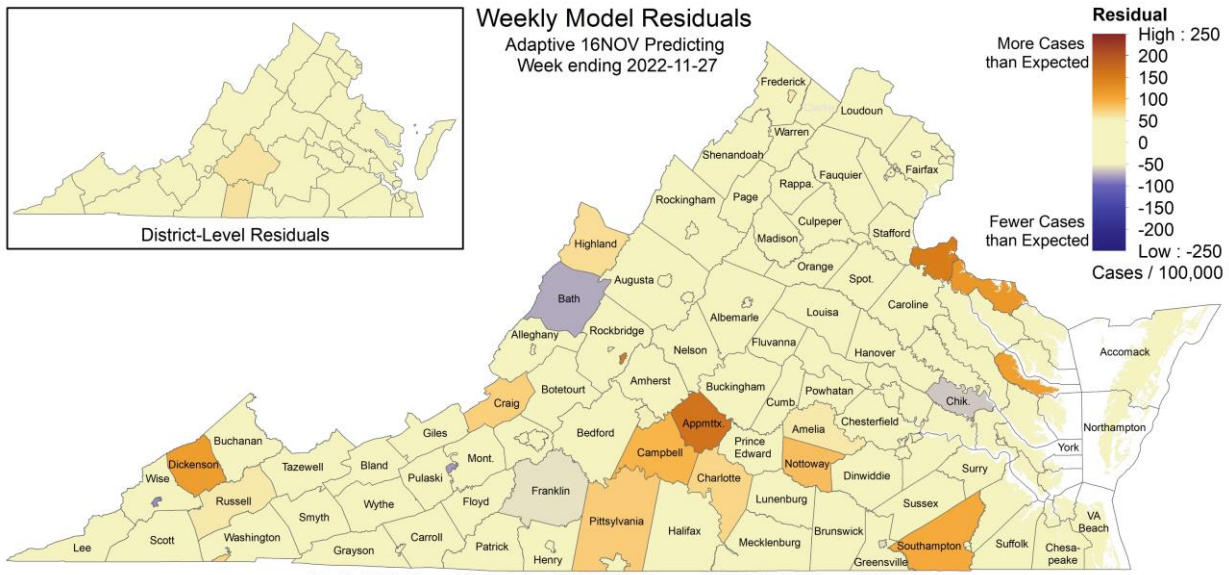
## Spatial Hotspots

| Spot | Zip Code | Name | Conf. |
|---|---|---|---|
| 1 | 23829 | Capron* | 99% |
| 2 | 23413 | Nassawadox | 99% |
| 3 | 23063 | Goochland* | 95% |

Only zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.


Based on Global Empirical Bayes smoothed point prevalence for week ending 2022-11-28.

## Clustered Temporal Hotspots

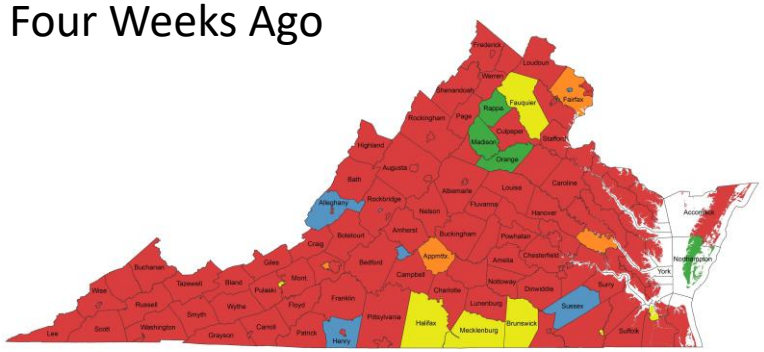



Health District Level Moran's I = -0.006966, Z-Score = 0.377393, P-Value = 0.705882
No Residual Autocorrelation Detected

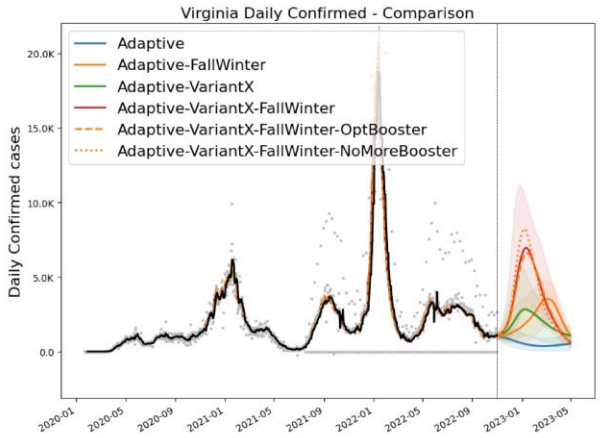
# Scenario Trajectory Tracking

**Which scenario from a month ago did projection for each county track closest?**

Four Weeks Ago



Two Weeks Ago







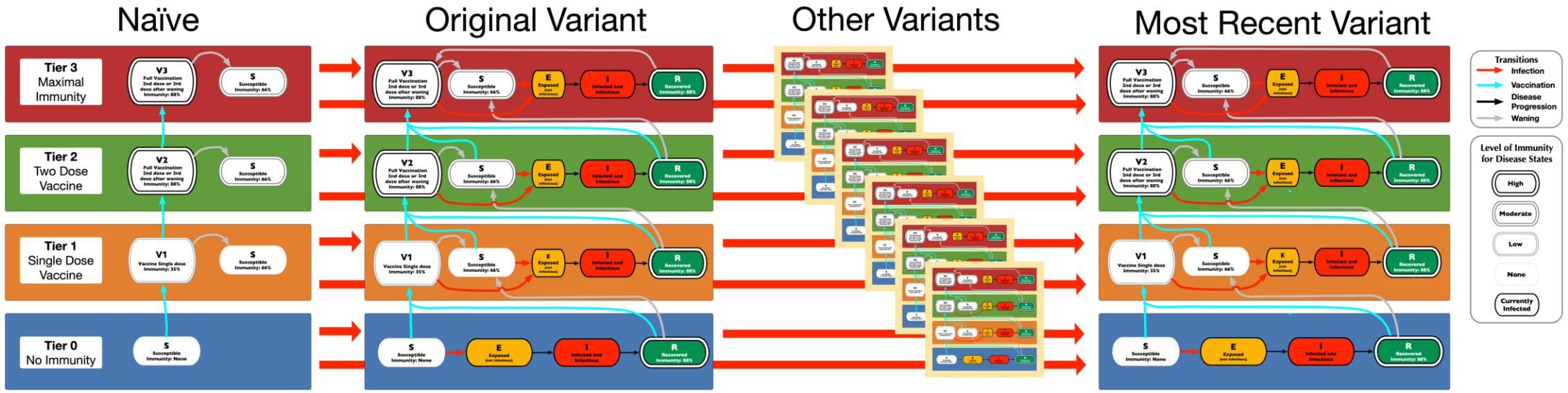
- One-month projections separate the scenarios more clearly and reveal larger overall patterns.
- Over the last six weeks, the Adaptive scenario forecasts have started to outperform those of FallWinter-VariantX in an increasing number of counties. Adaptive was most accurate in 82 of 133 locales this week.

# Model Update – Adaptive Fitting

# Model Structure Extended for more sub-variants

**Omicron sub-variants escape immunity induced by previous sub-variants**

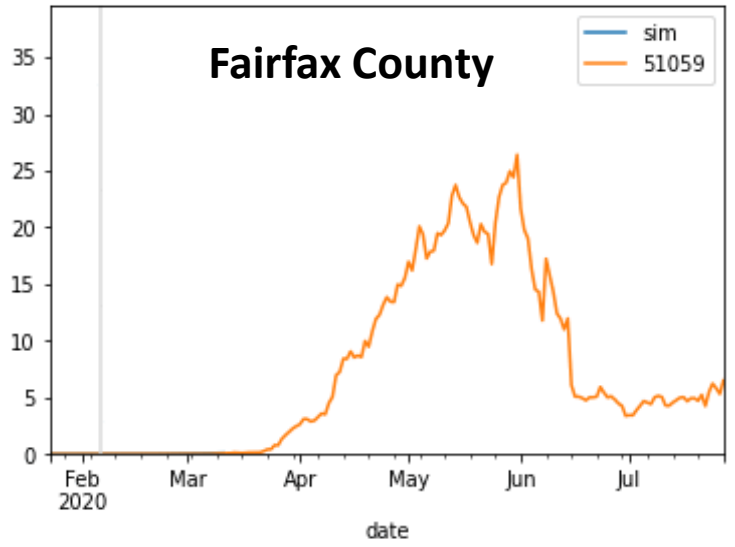
- Multiple strain support allows representation of differential protection based on immunological history (BA.1, BA.2, BA.2.12.1, BA.4/5, and future variants (VariantX) )
- Each sub-variant has differing levels of immune escape to previous sub-variants, the prevalences are based on observations for fitting purposes, and projections use estimated future prevalences
- Adaptive fitting approach continues to use simulation to generate the full distribution of immune states across the population



# Adaptive Fitting Approach

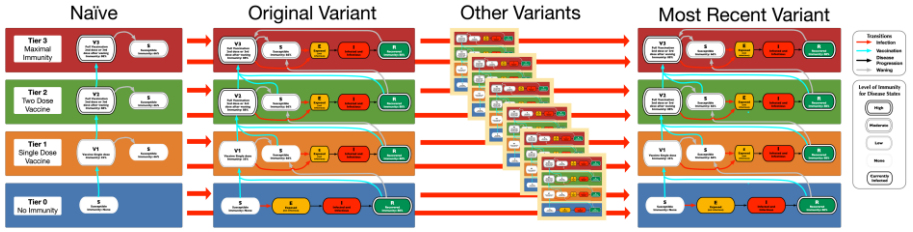
**Each county fit precisely, with recent trends used for future projection**

- Allows history to be precisely captured, and used to guide bounds on projections




**Model:** An alternative use of the same meta-population model, PatchSim with multiple tiers of immunity

- Allows for future "what-if" Scenarios to be layered on top of calibrated model
- Allows for waning of immunity and for partial immunity against different outcomes (eg lower protection for infection than death)

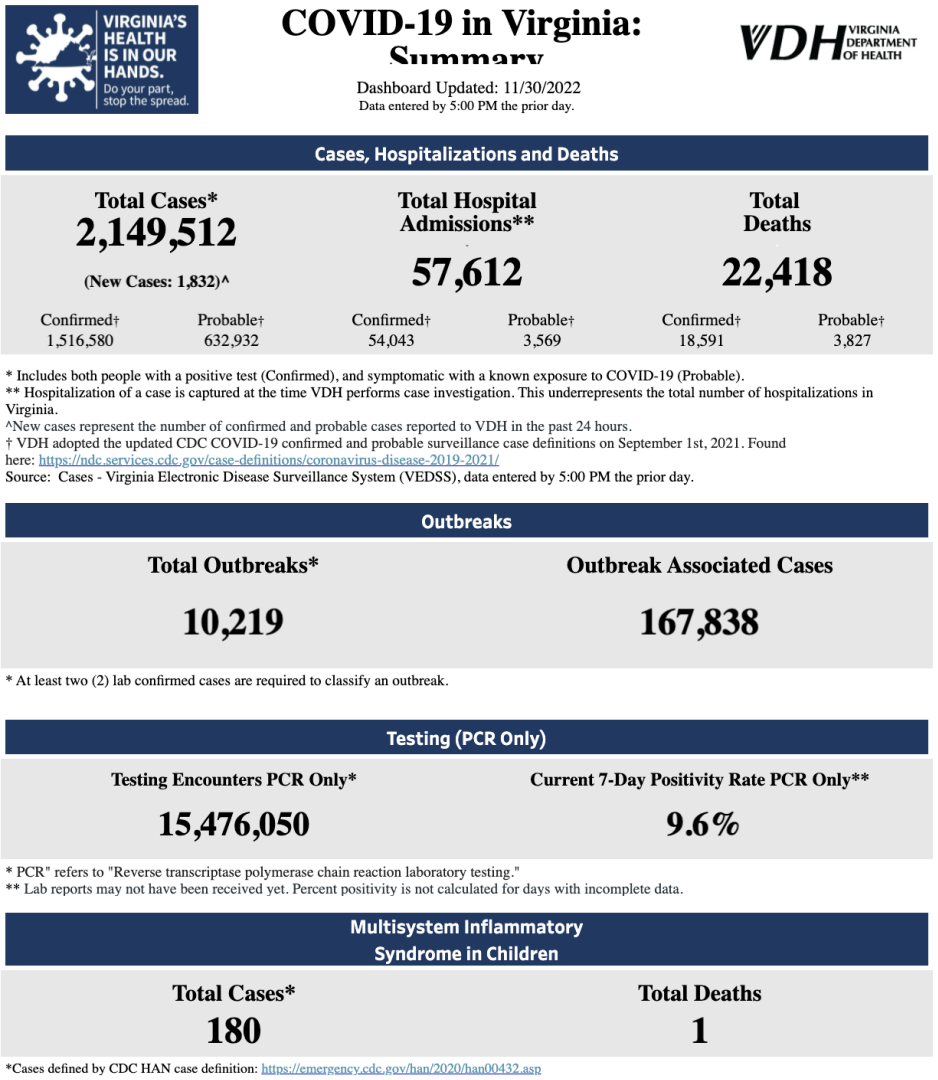



**External Seeding:** Steady low-level importation

- Widespread pandemic eliminates sensitivity to initial conditions, we use steady 1 case per 10M population per day external seeding

# Calibration Approach

- **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting
- **Calibration:** fit model to observed data and ensemble's forecast
  - Tune transmissibility across ranges of:
    - Duration of incubation (5-9 days), infectiousness (3-7 days)
    - Undocumented case rate (1x to 7x) guided by seroprevalence studies
    - Detection delay: exposure to confirmation (4-12 days)
  - Approach captures uncertainty, but allows model to precisely track the full trajectory of the outbreak
- **Project:** future cases and outcomes generated using the collection of fit models run into the future
  - **Mean trend from last 7 days of observed cases and first week of ensemble's forecast used**
  - Outliers removed based on variances in the previous 3 weeks
  - 2 week interpolation to smooth transitions in rapidly changing trajectories
- **Outcomes**: Data driven by shift and ratio that has least error in last month of observations
  - Hospitalizations: 3 days from confirmation, 6.8% of cases hospitalized
  - Deaths: 11 days from confirmation, 1.45% of cases die



VIRGINIA'S HEALTH IS IN OUR HANDS. Do your part, stop the spread.

**COVID-19 in Virginia: Summary**

VDH VIRGINIA DEPARTMENT OF HEALTH

Dashboard Updated: 11/30/2022
Data entered by 5:00 PM the prior day.

**Cases, Hospitalizations and Deaths**

| Total Cases* | Total Hospital Admissions** | Total Deaths |
|---|---|---|
| 2,149,512 | 57,612 | 22,418 |
| (New Cases: 1,832)^ | | |

| Confirmed† | Probable† | Confirmed† | Probable† | Confirmed† | Probable† |
|---|---|---|---|---|---|
| 1,516,580 | 632,932 | 54,043 | 3,569 | 18,591 | 3,827 |

* Includes both people with a positive test (Confirmed), and symptomatic with a known exposure to COVID-19 (Probable).
** Hospitalization of a case is captured at the time VDH performs case investigation. This underrepresents the total number of hospitalizations in Virginia.
^New cases represent the number of confirmed and probable cases reported to VDH in the past 24 hours.
† VDH adopted the updated CDC COVID-19 confirmed and probable surveillance case definitions on September 1st, 2021. Found here: https://ndc.services.cdc.gov/case-definitions/coronavirus-disease-2019-2021/
Source: Cases - Virginia Electronic Disease Surveillance System (VEDSS), data entered by 5:00 PM the prior day.

**Outbreaks**

| Total Outbreaks* | Outbreak Associated Cases |
|---|---|
| 10,219 | 167,838 |

* At least two (2) lab confirmed cases are required to classify an outbreak.

**Testing (PCR Only)**

| Testing Encounters PCR Only* | Current 7-Day Positivity Rate PCR Only** |
|---|---|
| 15,476,050 | 9.6% |

* PCR" refers to "Reverse transcriptase polymerase chain reaction laboratory testing."
** Lab reports may not have been received yet. Percent positivity is not calculated for days with incomplete data.

**Multisystem Inflammatory Syndrome in Children**

| Total Cases* | Total Deaths |
|---|---|
| 180 | 1 |

*Cases defined by CDC HAN case definition: https://emergency.cdc.gov/han/2020/han00432.asp

Accessed 11:30am November 30, 2022
https://www.vdh.virginia.gov/coronavirus/

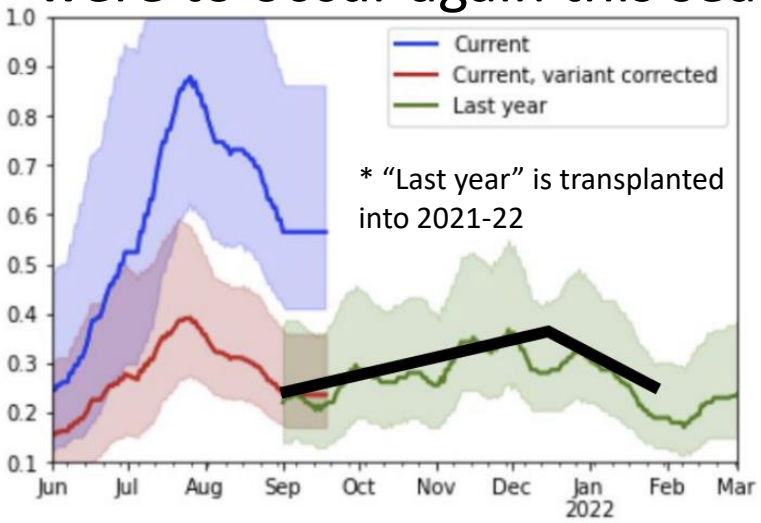
# Scenarios – Transmission Conditions

- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- **Waning Immunity**: Omicron waning with a mean of 4 months
- **Projection Condition Ingredients**:
  - **Adaptive:** Controls remain as currently experienced into the future with NO influence from other conditions (eg seasonal, variants, etc.)
  - **Seasonal (Fall-Winter boosting):** Controls remain the same, however, seasonal forcing similar to past Fall-Winter waves is added from Sept-Feb
  - **Vaccine Booster Campaign (Booster):** Reformulated booster available this fall provides improved immunity against Omicron sub-variants
  - **New Variants (VariantX)**: As of yet unidentified novel sub-variant with similar immune escape but no transmission advantage emerges 4 months after the last significant sub-variant and grows at a similar rate

# Scenarios – FallWinter

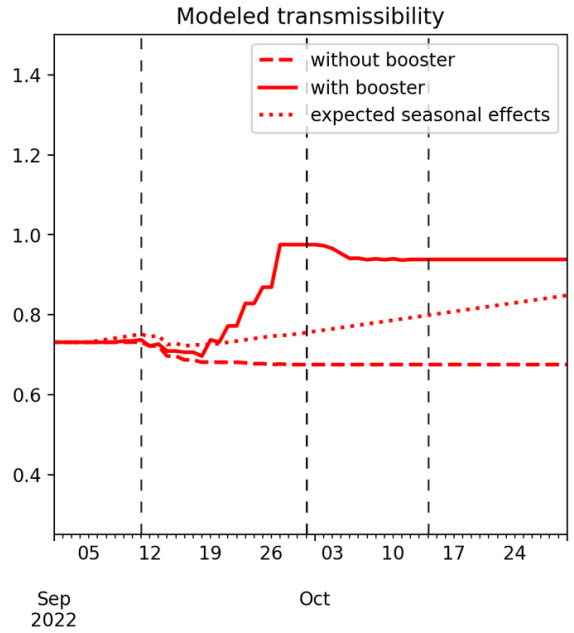
**September – February saw strong waves of transmission for both years**

- Based on analyses of the past 2 seasons we generate a “coarse baseline transmission boost”
  - In 2021 the distribution of fitted model transmissibility was nearly identical between these periods when corrected for Delta’s increased transmissibility
- **FallWinter** captures these “transmission drivers” from the past and uses them as if they were to occur again this season




**Fitting:** Black line represents the coarsely fitted base transmissibility

**2022 FallWinter is likely different:** With the current level of boosting the transmissibility needs to be much higher to maintain the same number of cases. The dotted line shows what transmission levels are needed to fit cases without booster and with seasonal effects.

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# Scenarios – Optimistic vs. Pessimistic Booster Coverage

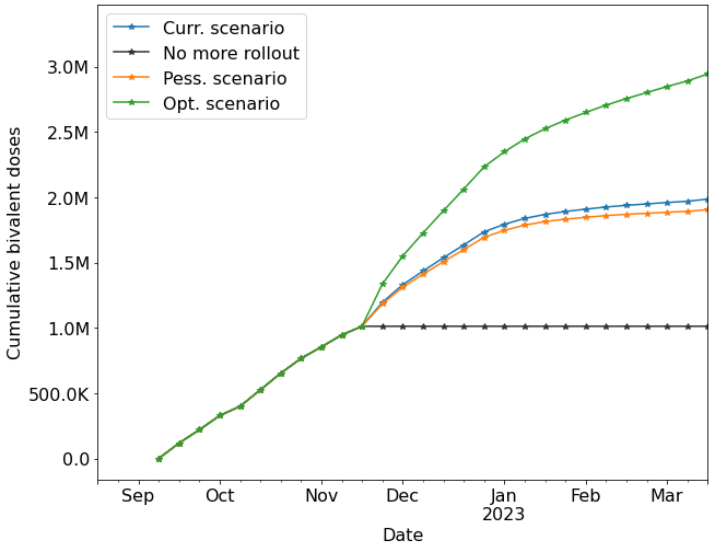
**Reformulated Boosters available now**

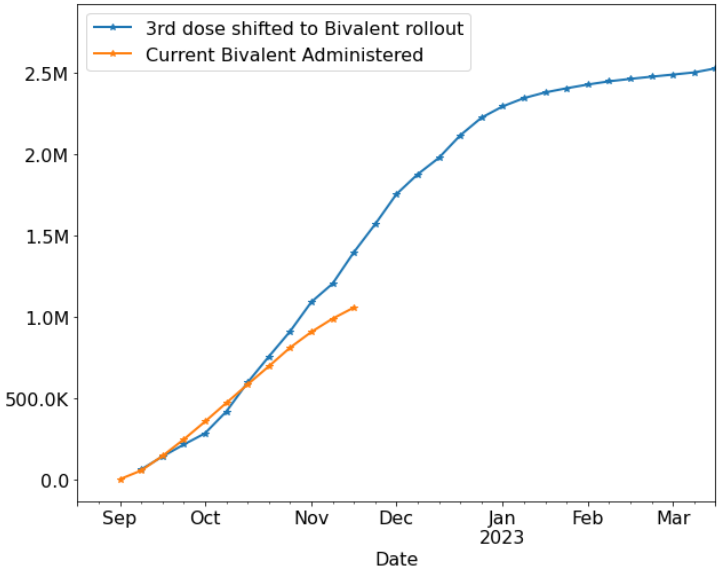
- Assume vax efficacy for BA.4/5 and previous variants is 80% against symptomatic illness
- Campaign follows current ground truth to present
- Variant X has same immune escape to these vaccines as against BA.5 (33%)

**Current pace:** Follows 3rd dose rollout, but maintains current pace relative to it (eg if slower, same slower rate continues into future)

**Optimistic pace**: 25% higher than previous 3rd dose schedule

**No More:** No further Bivalent boosters administered



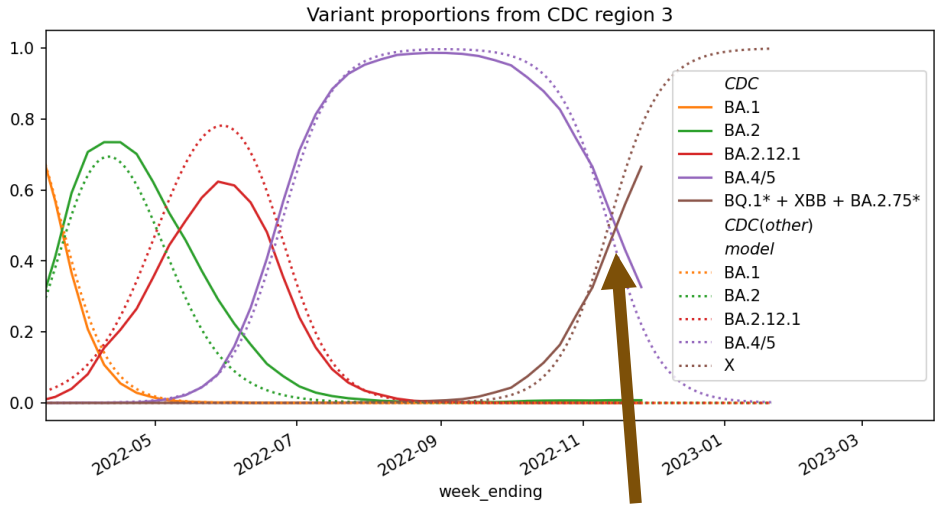



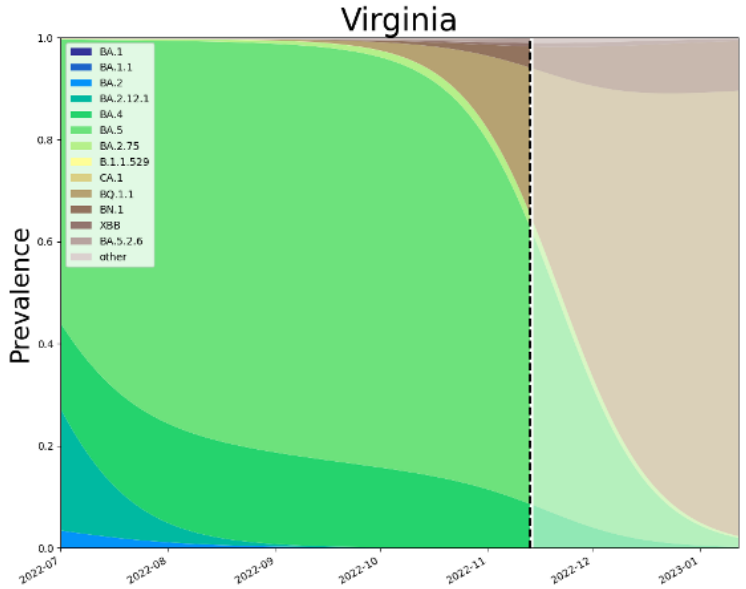
# Scenarios – Variant X

**Omicron sub-variants seem to be emerging and then dominating with some regularity**

- An increasingly complex soup of variants with demonstrated growth advantages in other countries and states continues to grow
- BQ.1.1, XBB, and others have shown evidence of significant immune escape, BQ.1.1 currently growing quickly in US and VA, it remains possible that several may simultaneously expand
- **VariantX** represents the next variant or the potential swarm of several. We assume similar growth and level of immune escape against previous sub-variants as BA.4/5 (same transmissibility and 30% immune escape against BA.4/5, higher for other sub-variants).

**Sub-Variants with Fitted Prevalences and Hypothetical Future waves**




Variant X reached 50% on Nov 12th

# Projection Scenarios – Combined Conditions

| Name | Txm | Variant | Booster | Description |
|---|---|---|---|---|
| Adaptive | C | SQ | Current | Likely trajectory based on conditions remaining similar to the current experience, includes immune escape due to Omicron |
| Adaptive-FallWinter | FallWinter | SQ | Current | Like Adaptive, with seasonal forcing of FallWinter added on |
| Adaptive-VariantX | C | X | Current | Like Adaptive, with emergence of a speculative unknown variant 4 months after BA.4/5 with similar level of immune escape and equal transmissibility |
| Adaptive-VariantX-FallWinter | FallWinter | X | Current | Like Adaptive-VariantX but with the seasonal force of FallWinter added on |
| Adaptive-VariantX-FallWinter-OptBooster | FallWinter | X | Optimistic | Like Adaptive-VariantX-Fall Winter but with Optimistic Booster (25% more than 3rd dose rollout) |
| Adaptive-VariantX-FallWinter-NoMoreBooster | FallWinter | X | No More | Like Adaptive-VariantX-FallWinter but with no additional Booster doses |

**Transmission:** C = Current levels persist into the future
FallWinter = Transmission rates learned from Sept through February of past seasons are estimated and added as a seasonal boosting to baseline transmission rates

**Variant:** SQ = Status quo prevalences remain the same (e.g. no significant major driving of transmission anticipated)
X = Novel sub-variant scenario, new variant emerges reaches dominance in near term, 30% immune escape

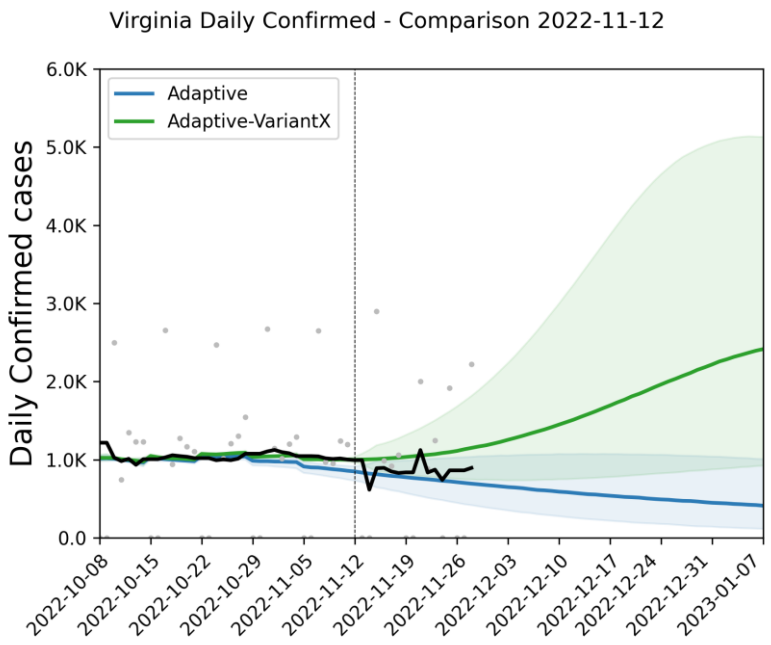
**Booster:** Current = Current pace relative to 3rd dose rollout is maintained in the future
Optimistic = Starting this week, additional 25% over the 3rd dose rollout is maintained into the future
No More = Starting this week, no additional doses of the booster are administered

# Model Results

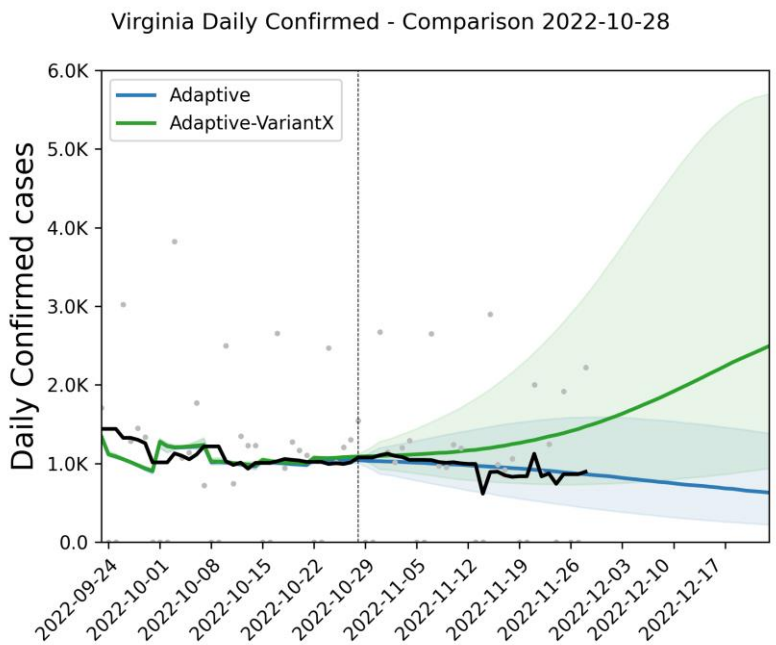
# Previous projections comparison - Cases

- Previous projections continue to track observed cases
- Projection from 2 weeks ago projected plateau a week after cases started to plateau
- Projection from 4 weeks ago projected slower decline better capturing recent slowing
- Projection from early July remains eerily on track

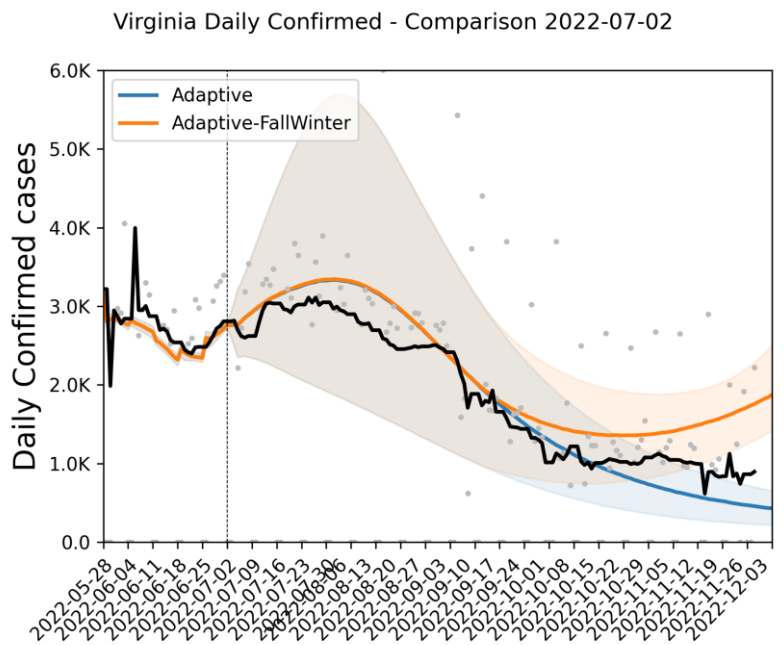
Previous round (2 weeks ago)




Projection from 4 weeks ago



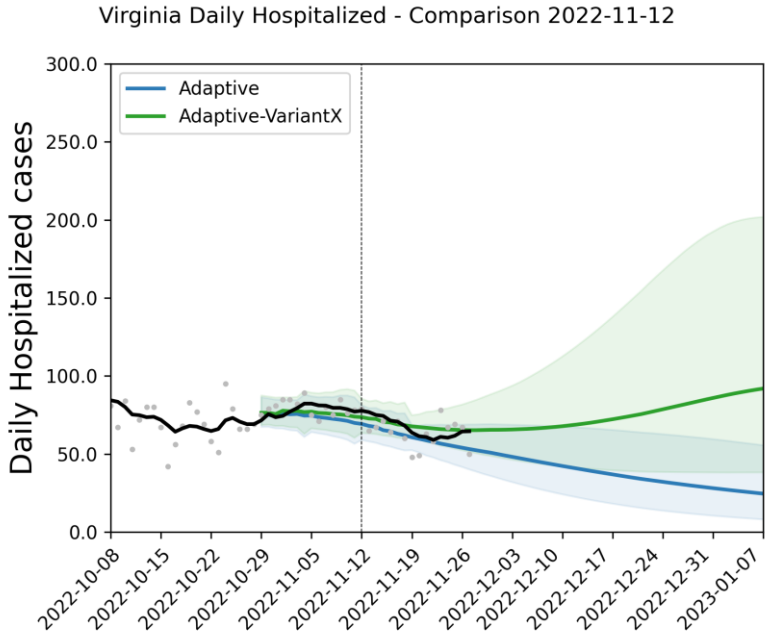

Projection from 3 months ago



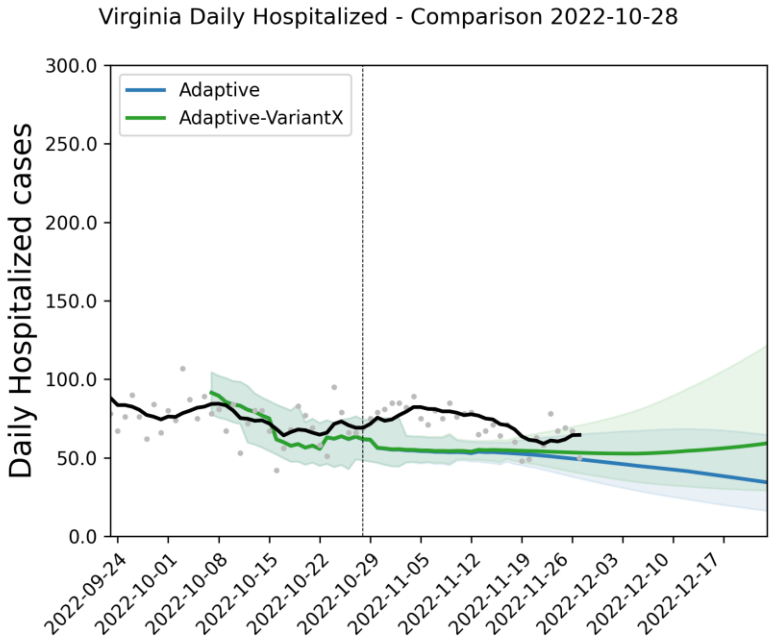
# Previous projections comparison - Hospitalizations

- Previous projections have tracked observed hospitalizations well
- Projection from 2 weeks ago projected continued decline, missed bump
- Projection from early July anticipated a plateau has tracked reasonably well up to present

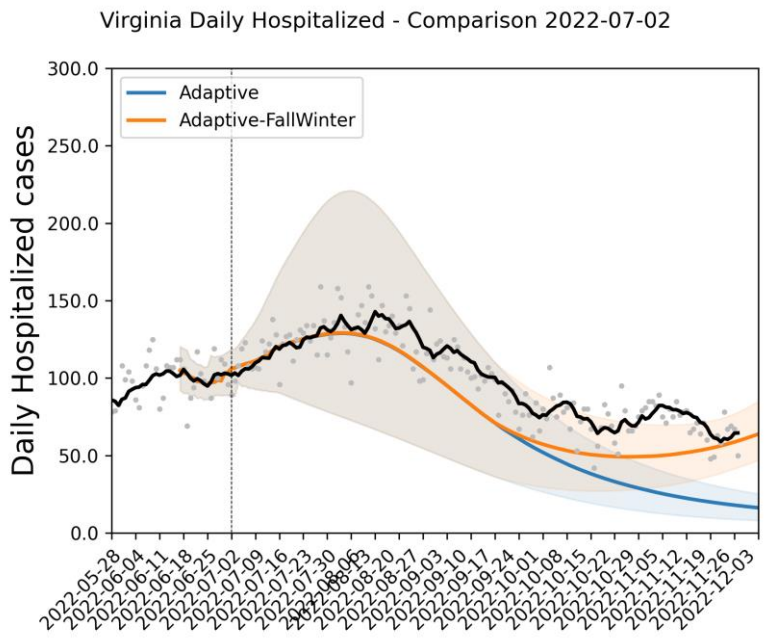
Previous round (2 weeks ago)




Projection from 4 weeks ago

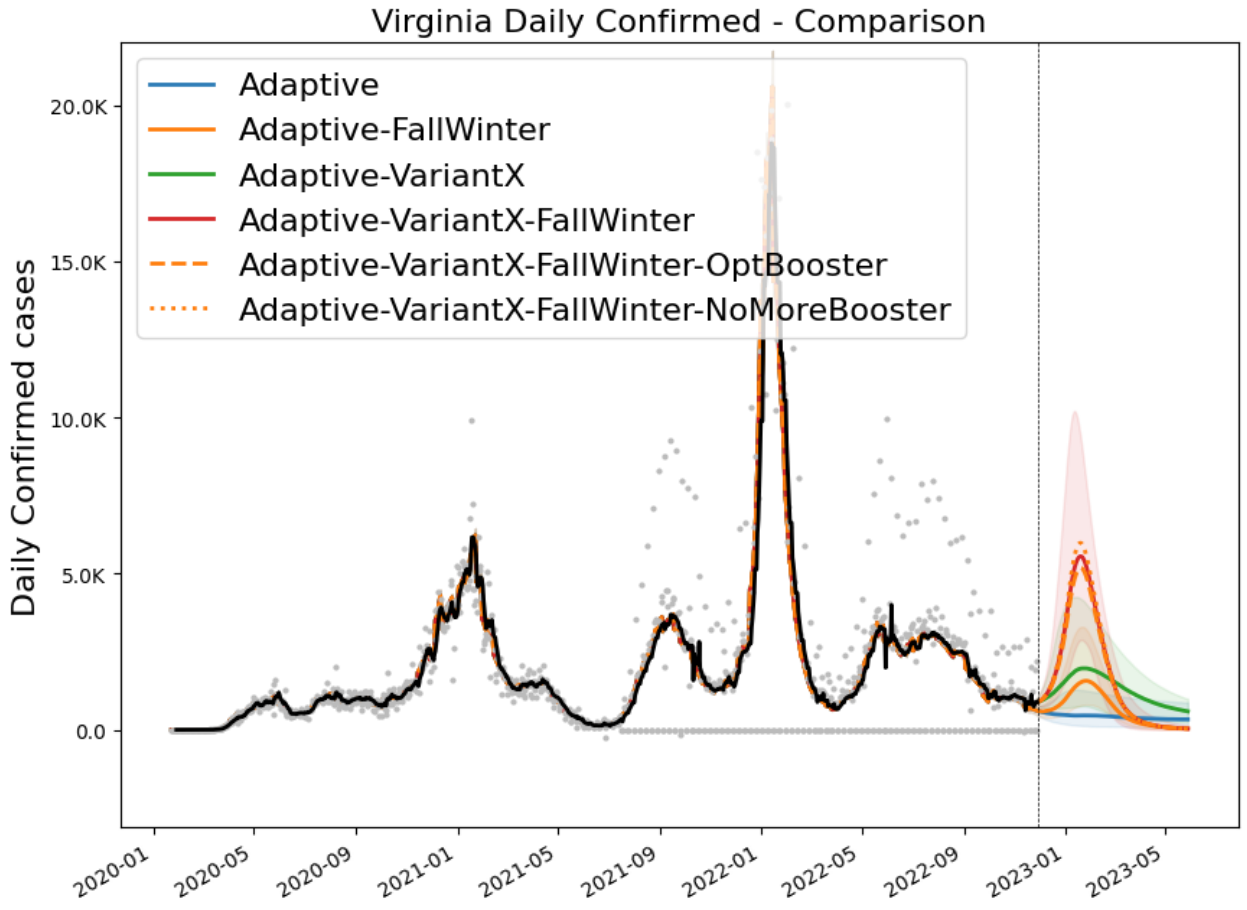



Projection from 3 months ago



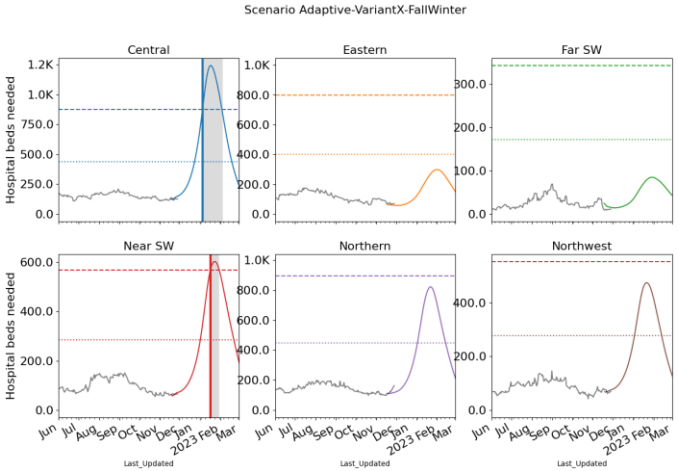
# Outcome Projections

## Confirmed cases

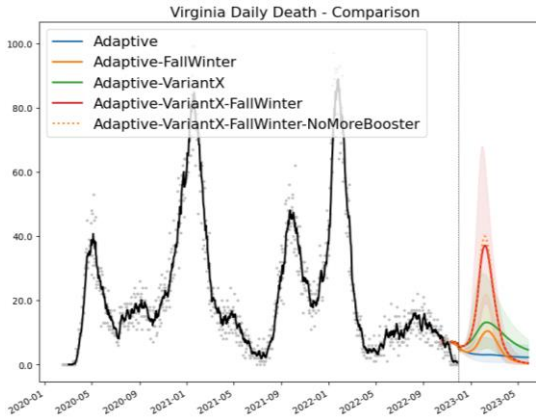



* without surveillance correction VariantBA2 peaked over 10K in July

## Estimated Hospital Occupancy

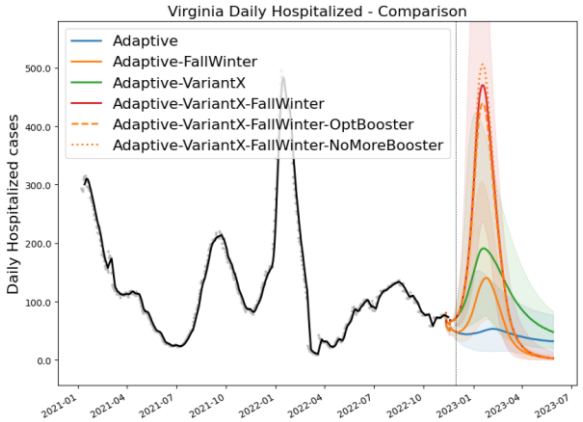



## Daily Deaths



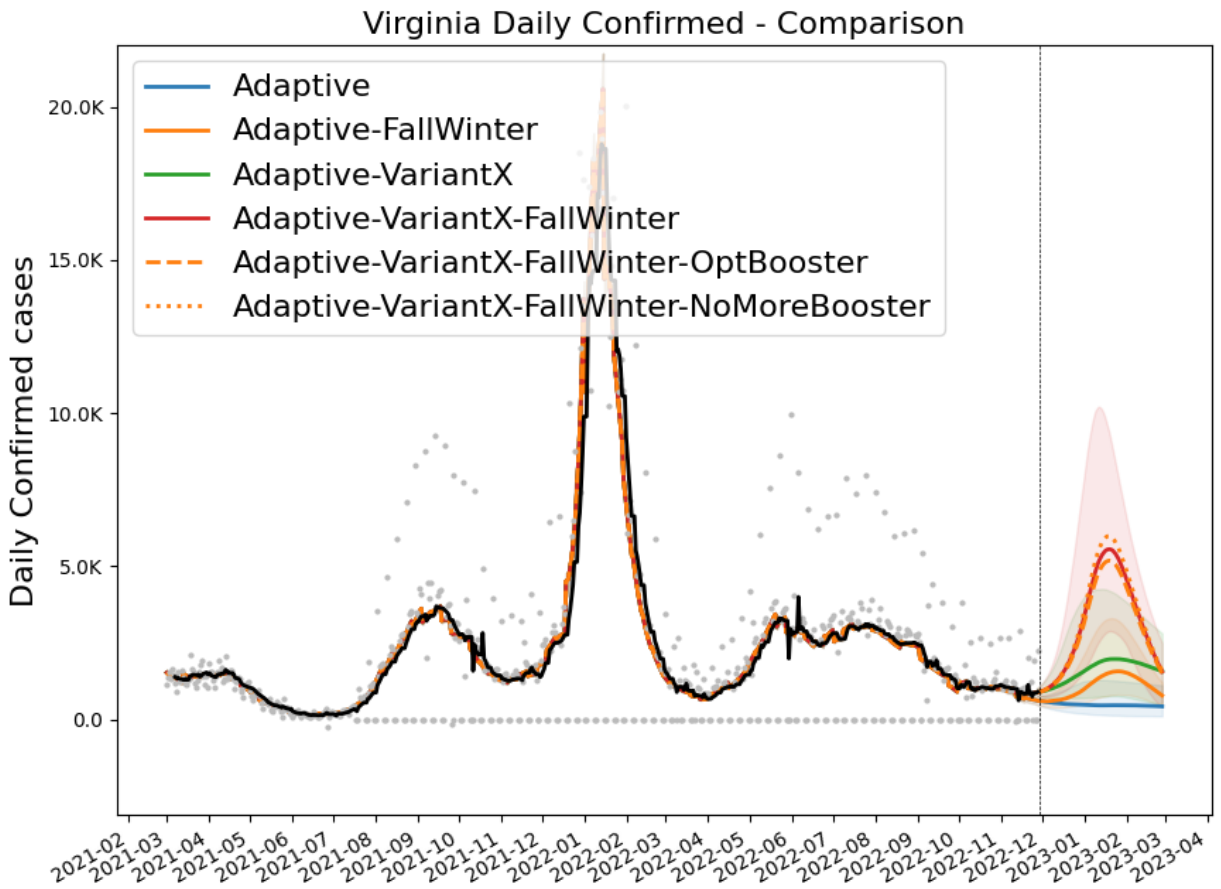

Death ground truth from VDH "Event Date" data, most recent dates are not complete

## Daily Hospitalized



# Outcome Projections – Closer Look

## Confirmed cases

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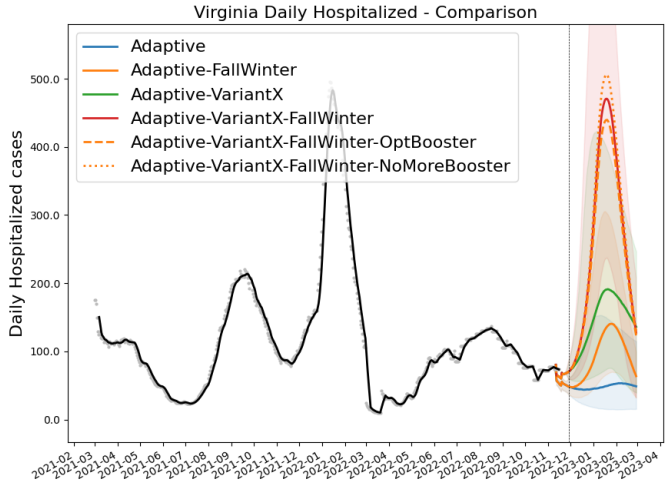
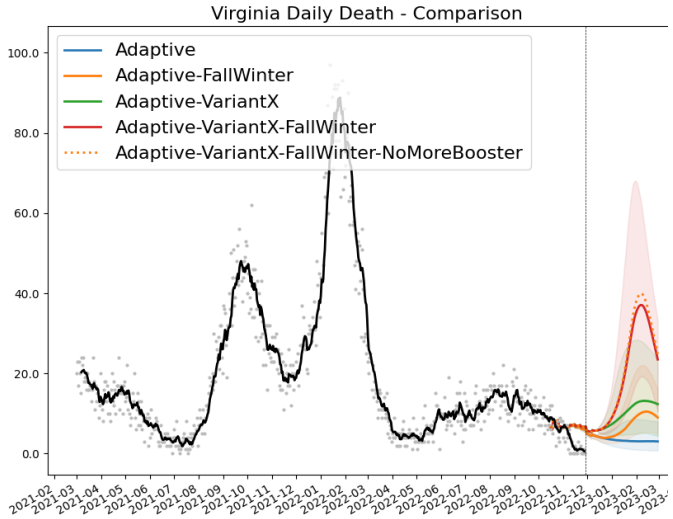
## Daily Hospitalized




## Daily Deaths




Death ground truth from VDH "Event Date" data, most recent dates are not complete

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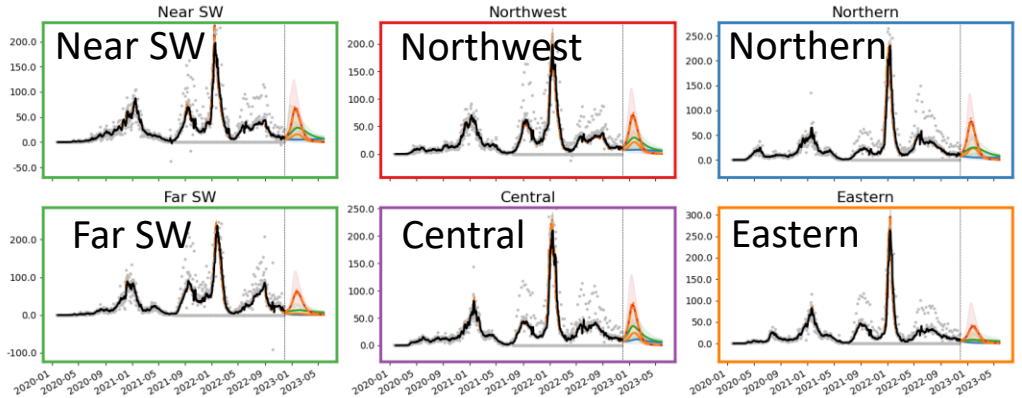
# Detailed Projections: Cases for All Scenarios

## Projections by Region



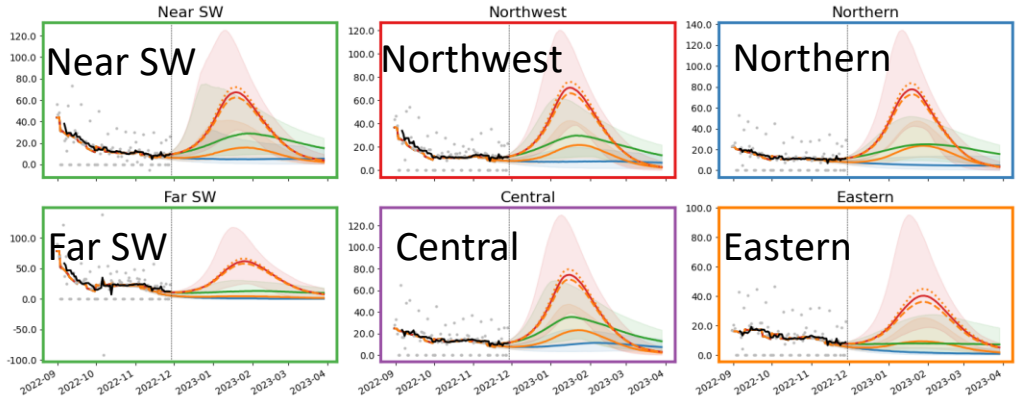

## Projections by District




Daily confirmed cases) by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

# Detailed Projections: Cases for All Scenarios - Closer Look

## Projections by Region



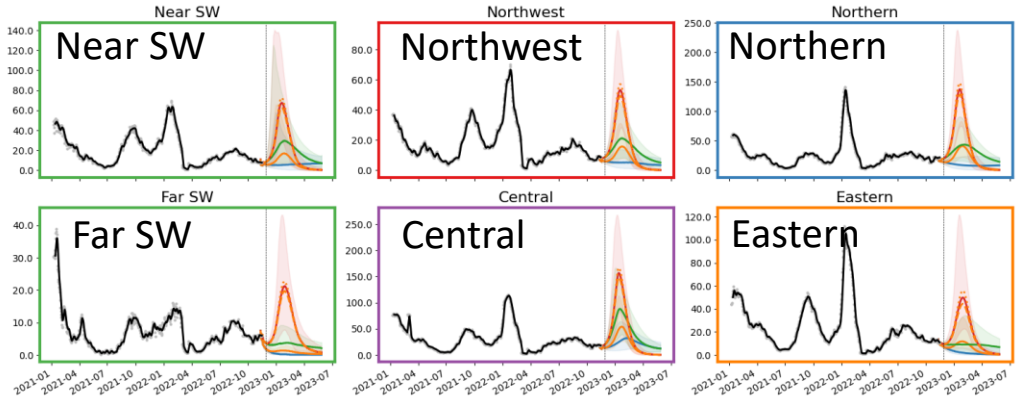

## Projections by District




Daily confirmed cases by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

# Detailed Projections: Hospitalizations for All Scenarios

## Projections by Region



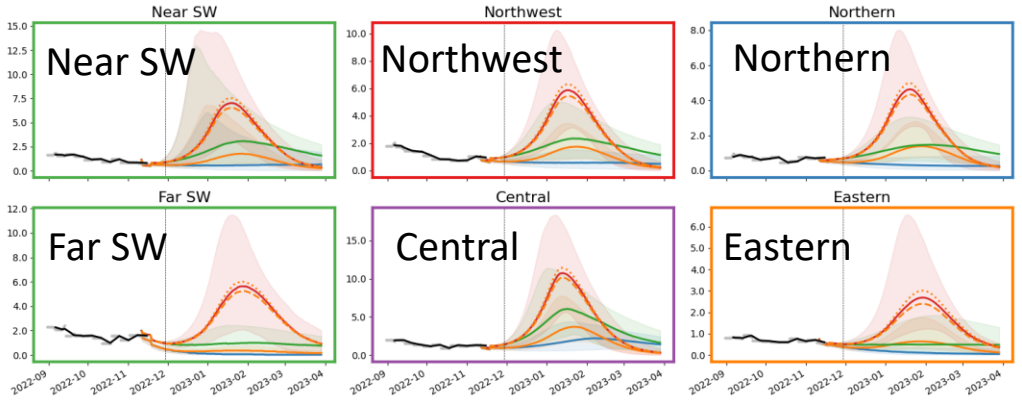

## Projections by District




Daily confirmed hospitalizations District (grey with 7-day average in black) with simulation colored by scenario

# Detailed Projections: Hosps for All Scenarios - Closer Look

## Projections by Region




## Projections by District



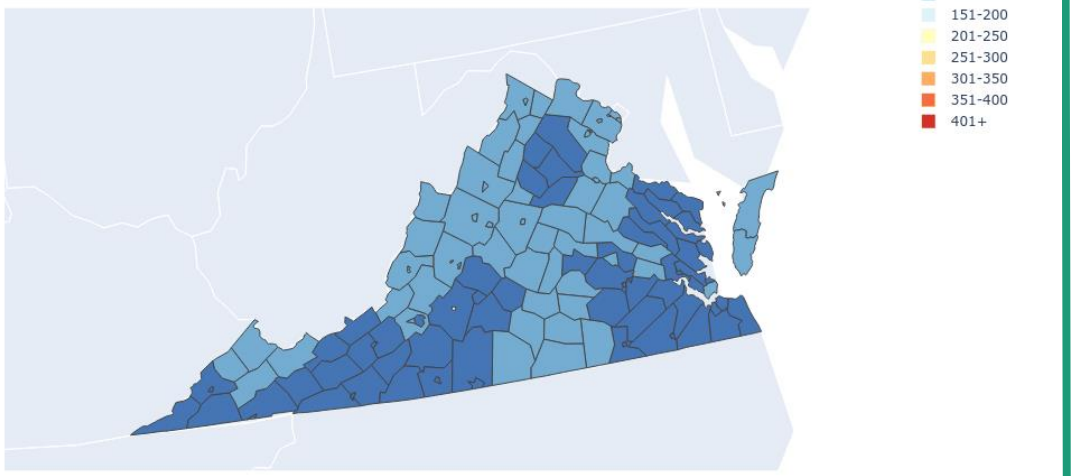

Daily confirmed hospitalizations District (grey with 7-day average in black) with simulation colored by scenario

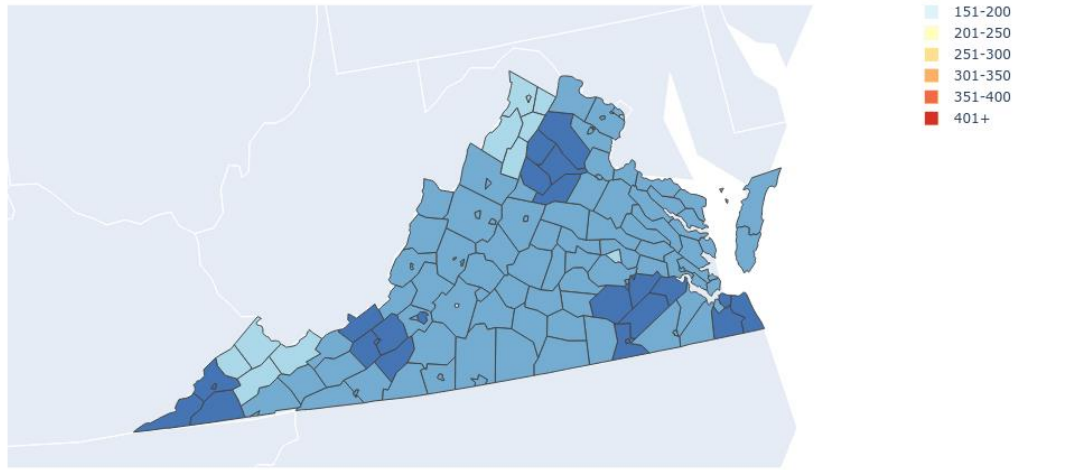
Adaptive

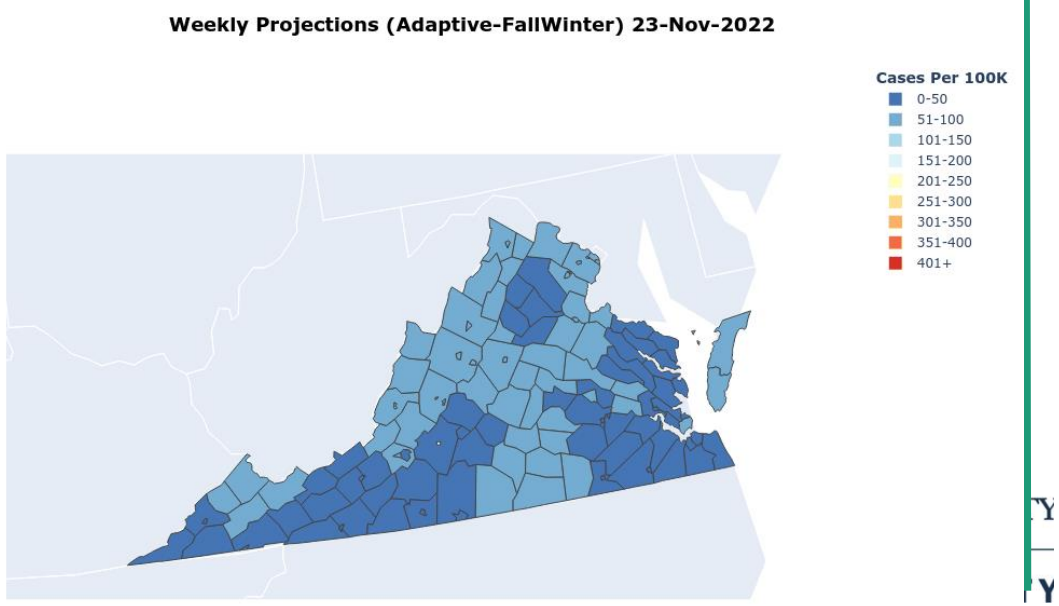
VariantX

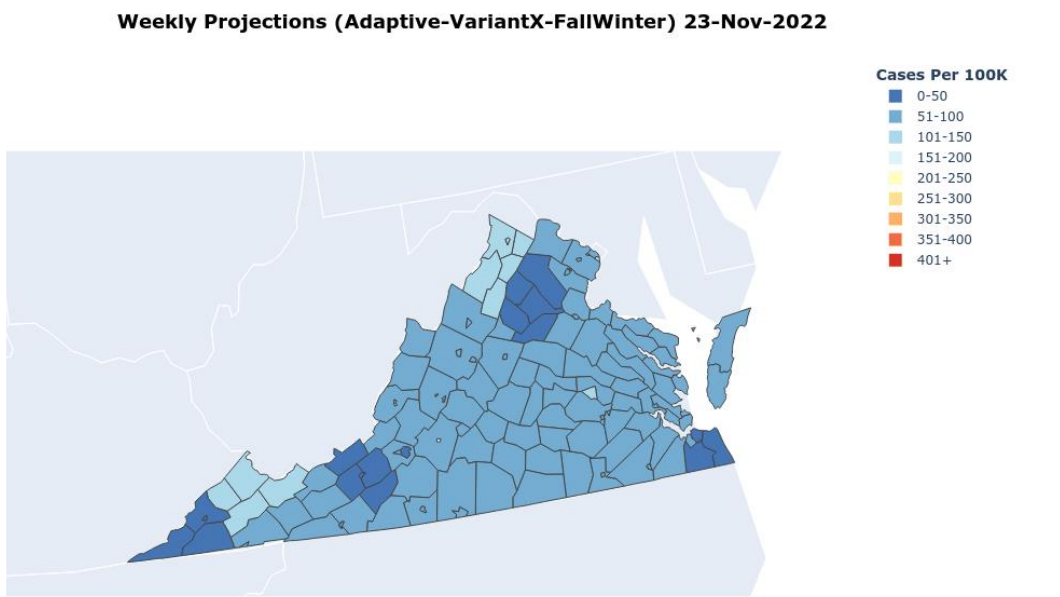
Adaptive

Adaptive-Fall-Winter



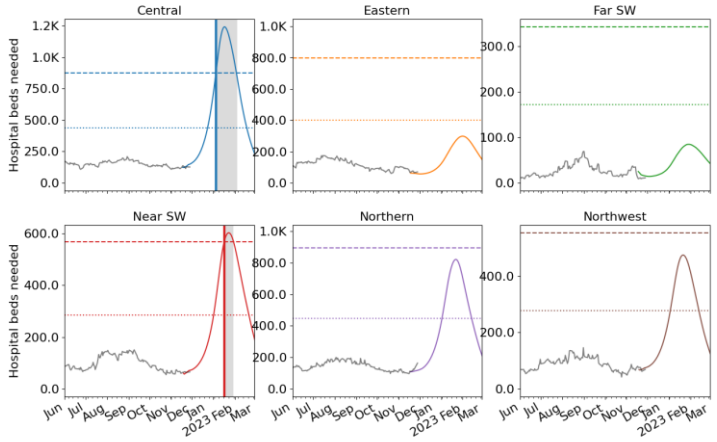



# Hospital Demand and Bed Capacity by Region

**Capacities by Region**

COVID-19 capacity ranges from 80% (dots) to 120% (dash) of total beds

**Adaptive – VariantX & Fall Winter**




**Length of Stay more variable with Omicron, occupancy projections may vary as a result, ad-hoc estimation performed per region**

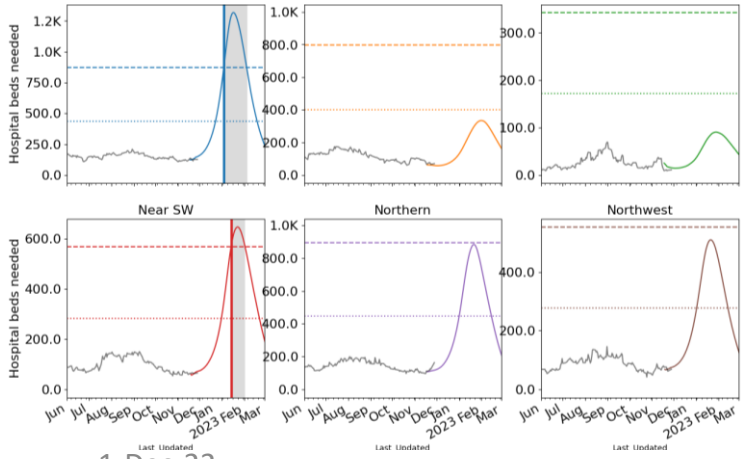
**Length of Stay Estimates**

| | |
|---|---|
| Central | 6 |
| Eastern | 6 |
| Far SW | 4 |
| Near SW | 9 |
| Northern | 5 |
| Northwestern | 9 |

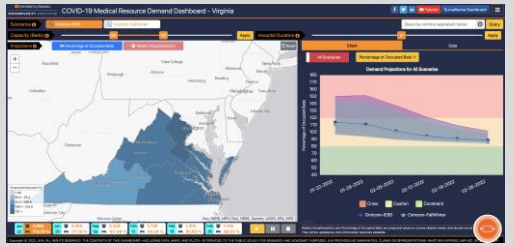
**Estimated LOS shortened slightly to better fit observed data**

**Projections show continued declines and with expanded capacities and adjusted length of stay, no capacities exceeded**

**Adaptive – VariantX & Fall Winter No More Booster**




Interactive Dashboard with regional projections



https://nssac.bii.virginia.edu/covid-19/vmrddash/

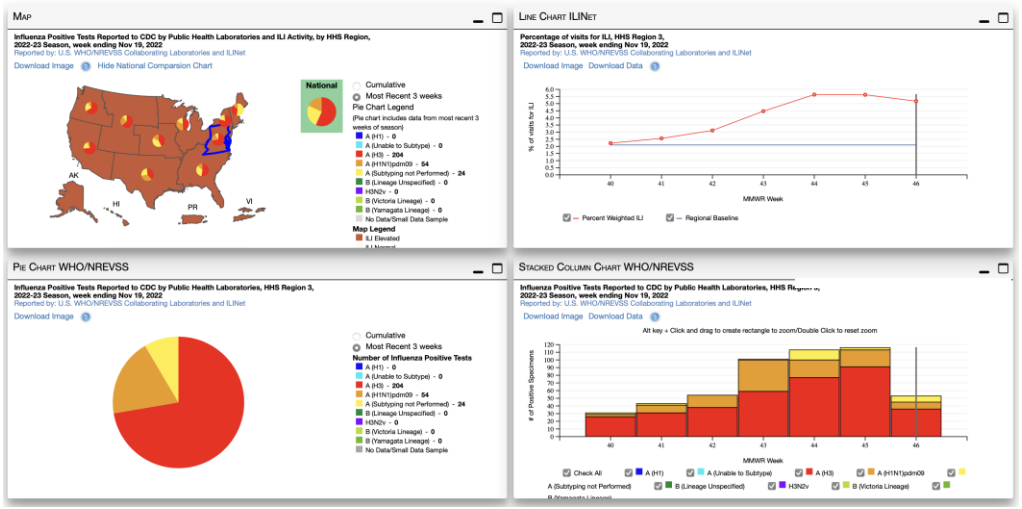
# Influenza Update

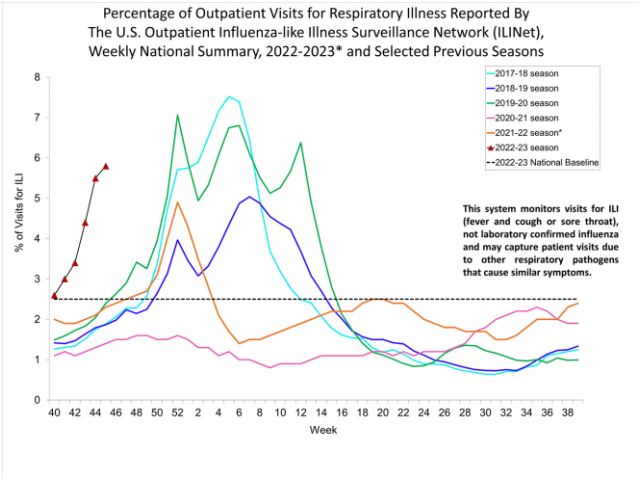
# Current Influenza Situation – ILI Activity

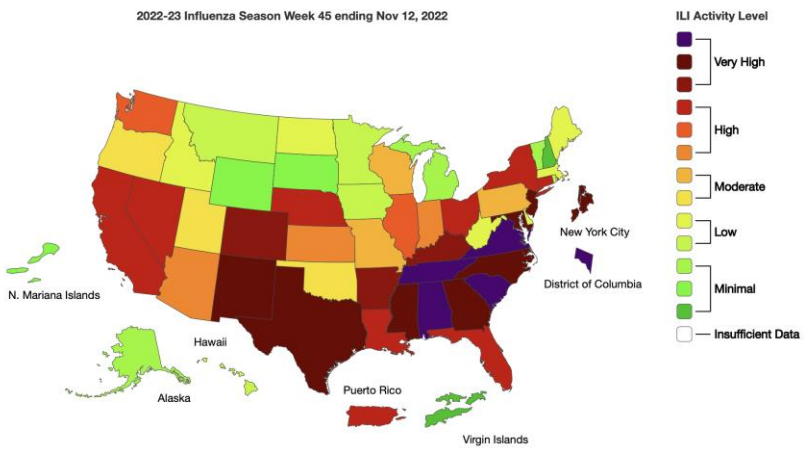
## Influenza Activity is  Higher than Usual

- Virginia at “Very High” activity along with much of the Southeast, with “High” activity shifting out across US
- In VA ILI Activity has receded from a high near ~12% of visits for ILI back to 7% this past week
- National ILI activity at highest before December since 2009 pandemic year which peaked in mid-Oct
- After starting with high proportions of H3N2 typed influenza, H1N1pdm09 now represents ~1/5 of all infections nationally

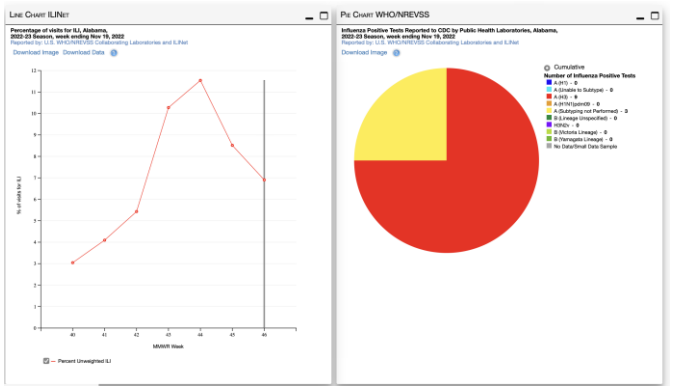
### Region 3




### Virginia

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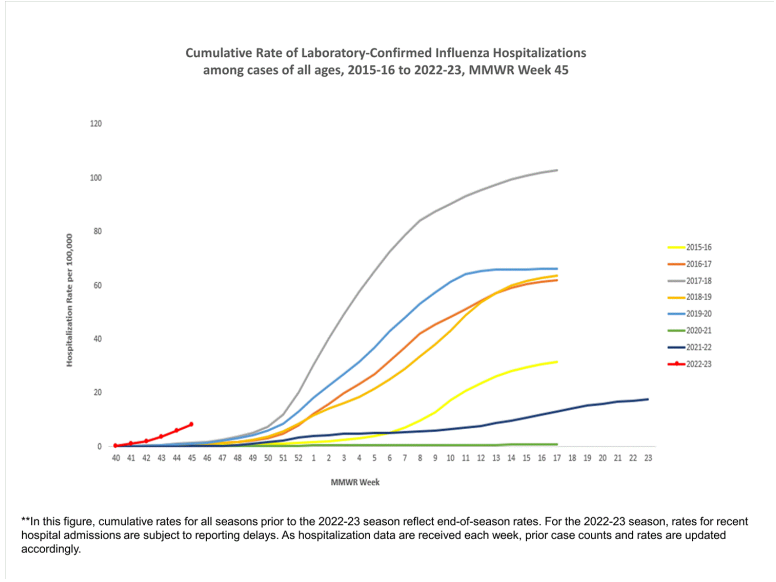
A Weekly Influenza Surveillance Report Prepared by the Influenza Division

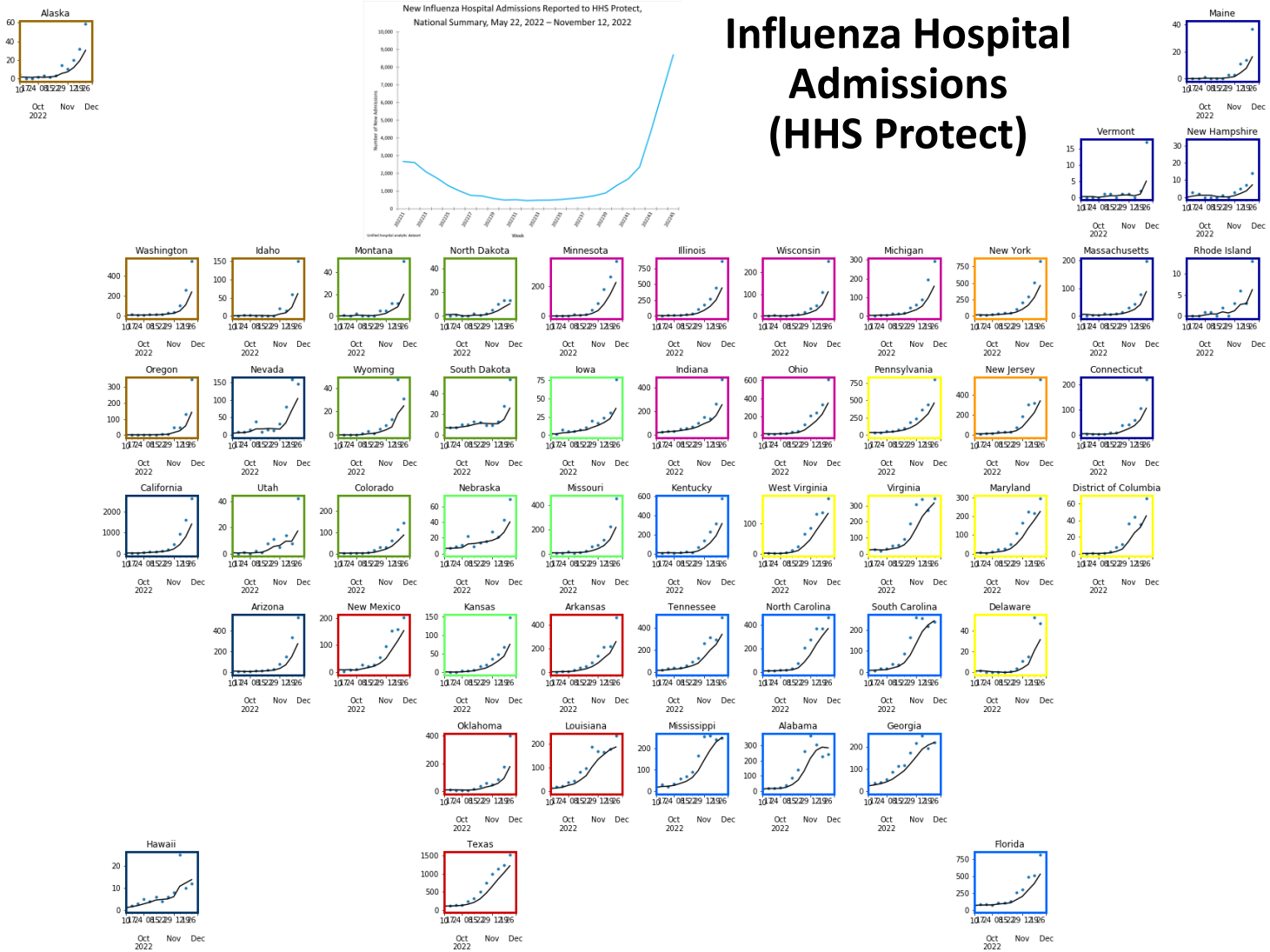
# Current Influenza Situation - Hospitalizations

## Influenza A hospitalizations continue rapid growth

- National level of influenza hospitalizations
- Nearly all states have doubled their hospitalizations due to influenza in the last couple weeks
- Virginia shows leveling off in the last weeks




**In this figure, cumulative rates for all seasons prior to the 2022-23 season reflect end-of-season rates. For the 2022-23 season, rates for recent hospital admissions are subject to reporting delays. As hospitalization data are received each week, prior case counts and rates are updated accordingly.




## Influenza Hospital Admissions (HHS Protect)

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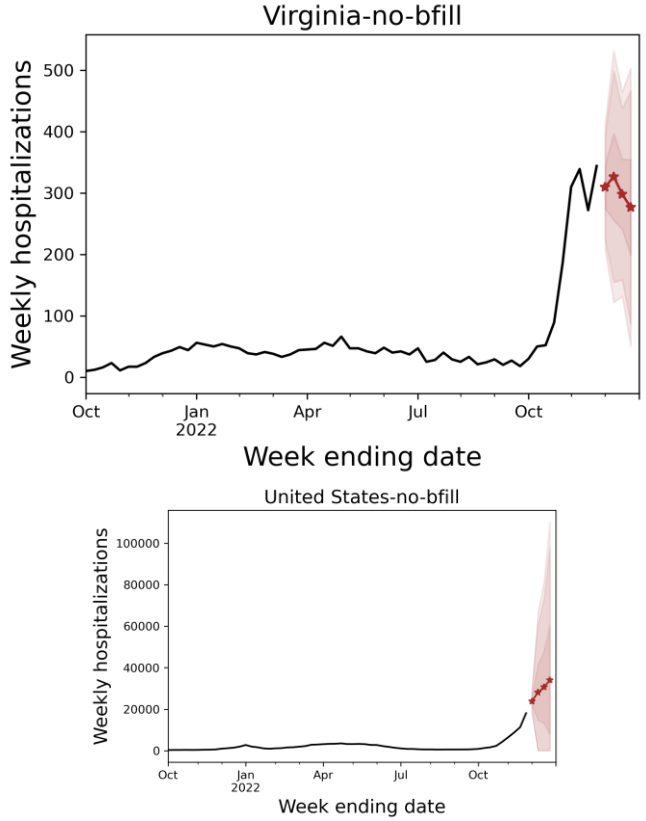
# Current Influenza Hospitalization Forecast

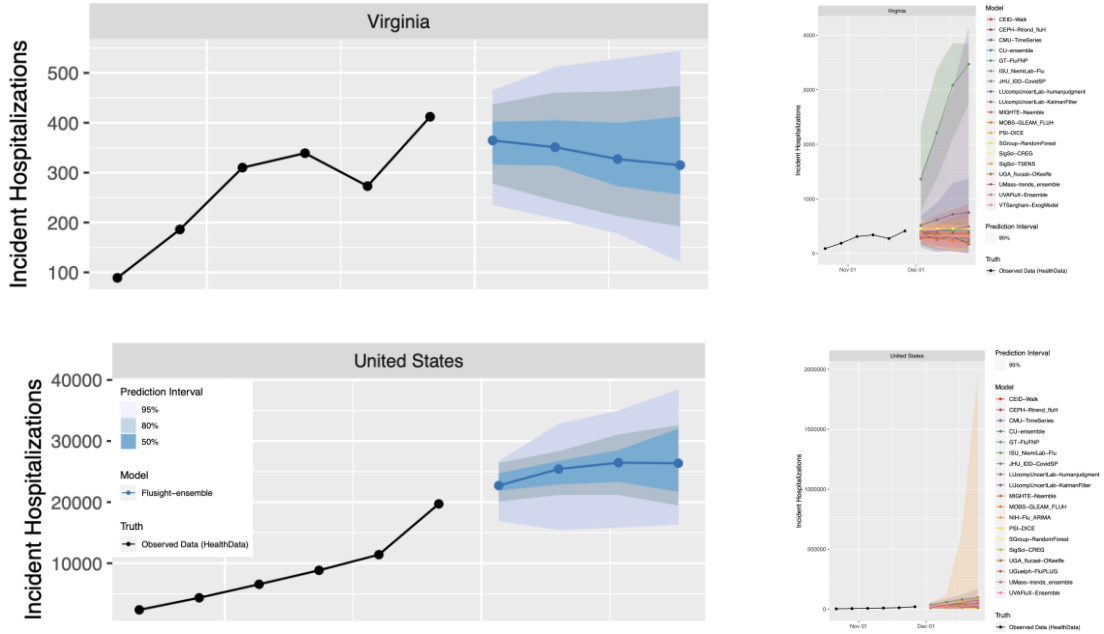
## Statistical models for submitting to CDC FluSight forecasting challenge

- Similar to COVID-19 case forecasts, uses a variety of statistical and ML approaches to forecast weekly hospital admissions for the next 4 weeks for all states in the US

### Hospital Admissions for Influenza and Forecast for next 4 weeks (UVA ensemble)




### Hospital Admissions for Influenza and Forecast for next 4 weeks (CDC FluSight Ensemble)

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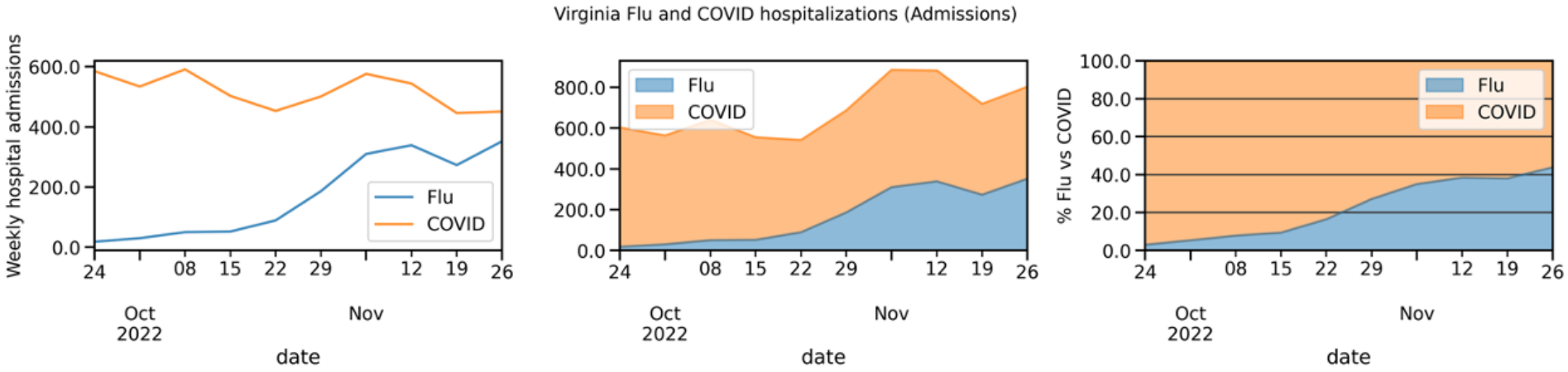
CDC FluSight

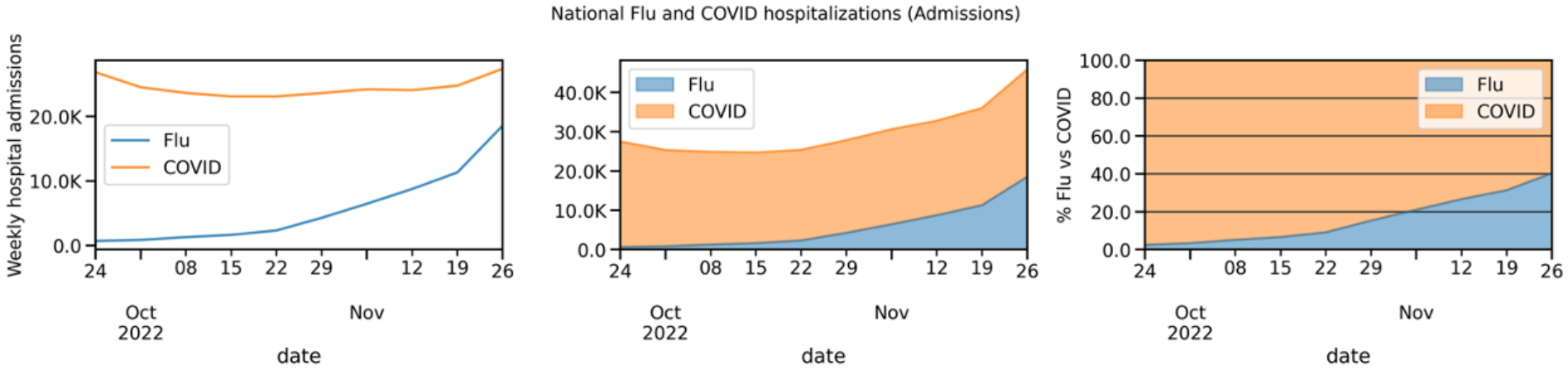
# Current Combined Hospitalizations (COVID-19 & Influenza)

**COVID-19 and Influenza Weekly Hospitalizations (HHS Protect)**

**Virginia**




**USA**



# Combined ILI and COVID-19 Hospitalizations

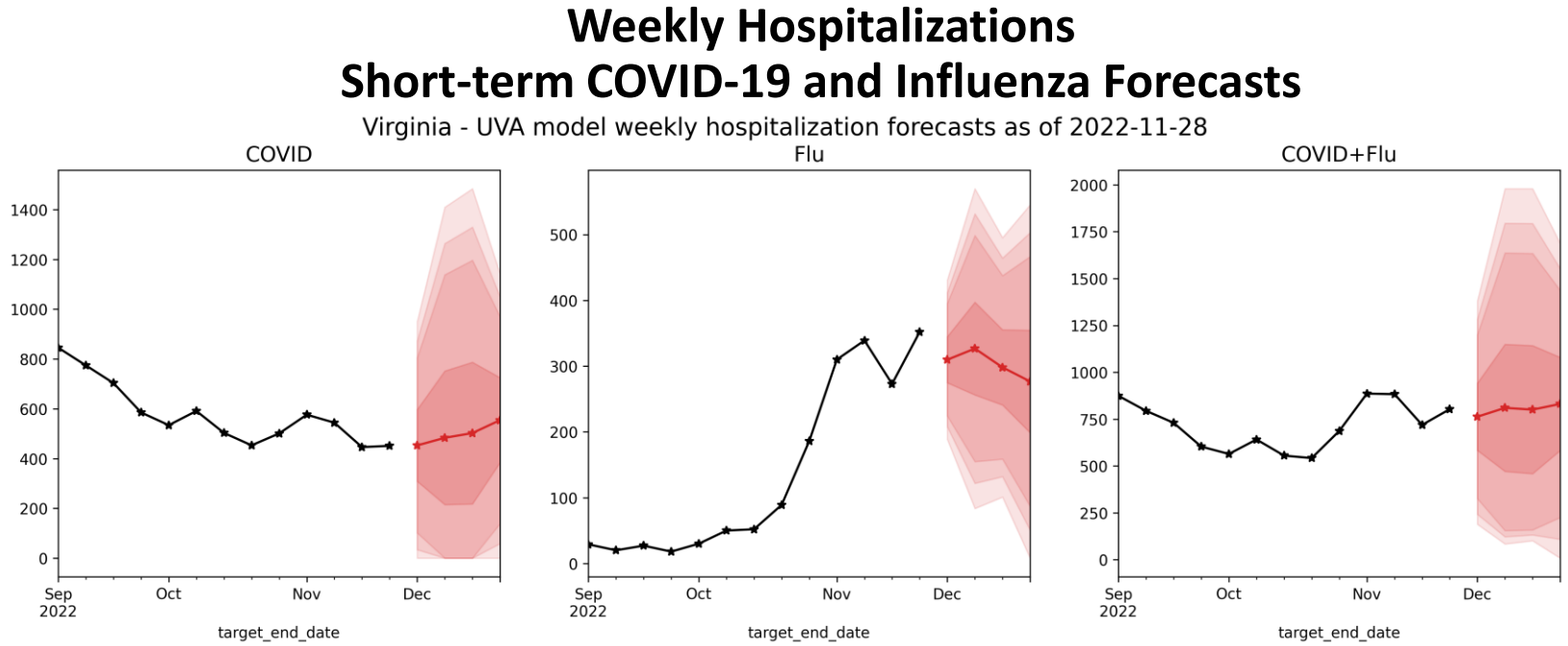
Ensemble methodology that combines the Adaptive with  machine learning and statistical models such as:

- Autoregressive (AR, ARIMA) , Neural networks (LSTM), Kalman filtering (EnKF), G-model (phase), Holt-Winters

Weekly forecasts of hospitalizations done at state level.

Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

Both are regularly submitted to CDC Forecast Hubs

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# National Modeling Hub Updates

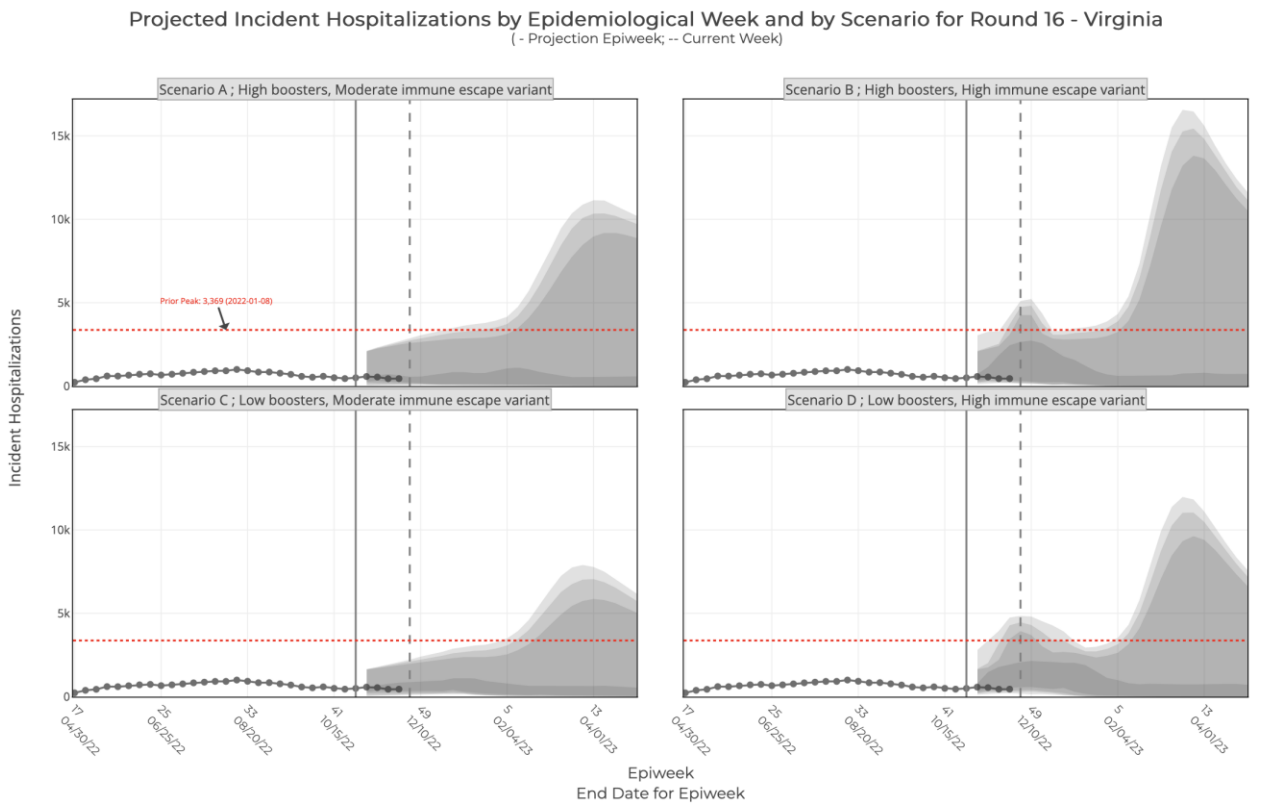
# Scenario Modeling Hub – COVID-19 (Round 16)

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios

- Round 16 results published

https://covid19scenariomodelinghub.org/viz.html

| | "Level 5" Variants | "Level 6/7" Variants |
|---|---|---|
| Accelerating uptake levels of reformulated boosters | Scenario A<br>"Level 5" Variants<br>- Variants have a 25% immune escape from BA.5.2<br>- Seeding based on combined observed prevalence of Level 5 variants at the start of the projection period<br>- No change in severity given symptomatic infection<br>**Accelerating uptake levels of reformulated boosters, with coverage plateauing at 90% of flu vaccination levels by February 1st, 2023**<br>- Teams are free to use available data and information from current and previous rollouts as tehy see fit to define rates<br>- Teams should assume increasing uptake through October and November as necessary to reach the projected February 1st, 2022 plateau | Scenario B<br>"Level 6/7" Variants<br>- Variants have a 50% immune escape from BA.5.2<br>- Seeding based on combined observed prevalence of Level 6 and 7 variants at the start of the projection period<br>- No change in severity given symptomatic infection<br>**Accelerating uptake levels of reformulated boosters, with coverage plateauing at 90% of flu vaccination levels by February 1st, 2023**<br>- Teams are free to use available data and information from current and previous rollouts as tehy see fit to define rates<br>- Teams should assume increasing uptake through October and November as necessary to reach the projected February 1st, 2022 plateau |
| Current uptake levels of reformulated boosters | Scenario C<br>"Level 5" Variants<br>- Variants have a 25% immune escape from BA.5.2<br>- Seeding based on combined observed prevalence of Level 5 variants at the start of the projection period<br>- No change in severity given symptomatic infection<br>**Current uptake levels of reformulated boosters, with coverage plateauing at booster 1 levels by the end of the simulation**<br>- Teams are free to use available data and information from current and previous rollouts as tehy see fit to define rates<br>- Based on current rates, plateau date is flexible as long as it occurs before the end of the simulation (Teams can adjust rates up if needed to achieve adequate coverage by target date) | Scenario D<br>"Level 6/7" Variants<br>- Variants have a 50% immune escape from BA.5.2<br>- Seeding based on combined observed prevalence of Level 6 and 7 variants at the start of the projection period<br>- No change in severity given symptomatic infection<br>**Current uptake levels of reformulated boosters, with coverage plateauing at booster 1 levels by the end of the simulation**<br>- Teams are free to use available data and information from current and previous rollouts as tehy see fit to define rates<br>- Based on current rates, plateau date is flexible as long as it occurs before the end of the simulation (Teams can adjust rates up if needed to achieve adequate coverage by target date) |



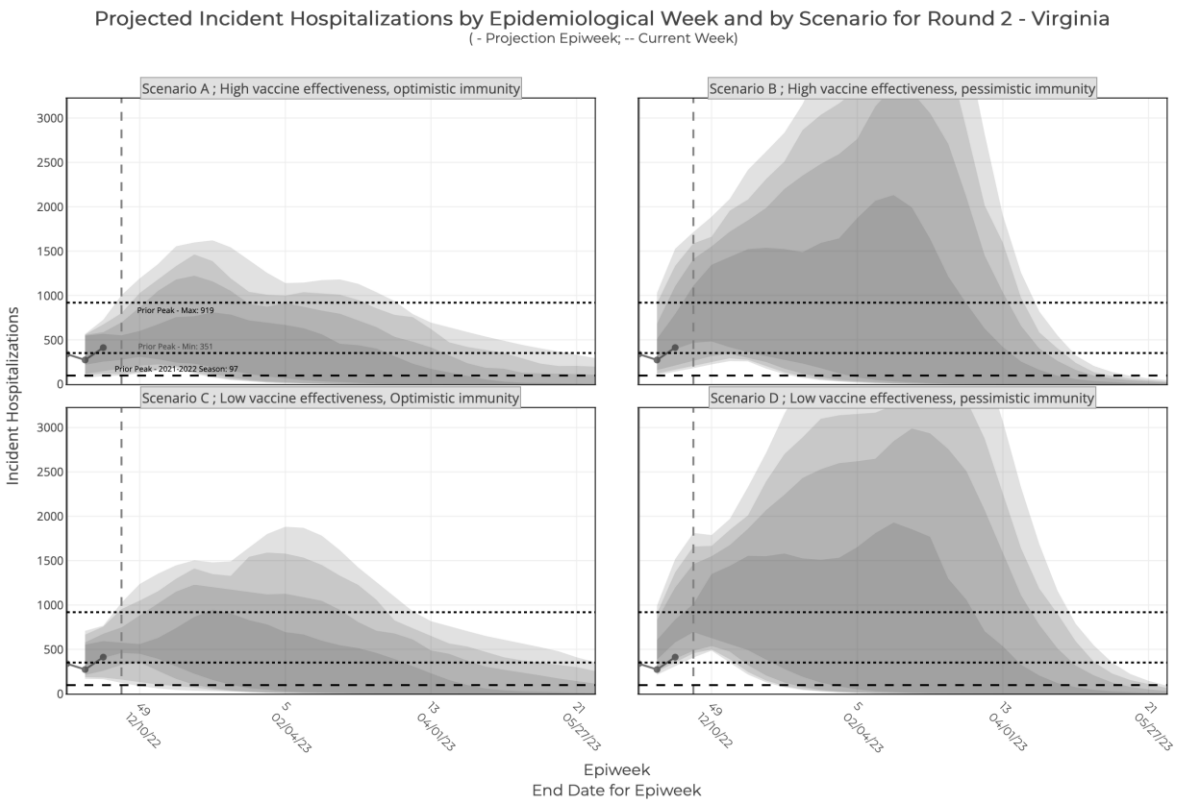
# Scenario Modeling Hub – Influenza (Round 2 - prelim)

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios

- Round 2 is more calibrated and similar to Round 1 but not complete

| | Optimistic flu prior immunity | Pessimistic flu prior immunity |
|---|---|---|
| High Vaccine Effectiveness | Scenario A<br>Optimistic flu prior immunity - No impact of missed flu seasons due to the COVID-19 pandemic on prior immunity.*<br>- Same amount of prior immunity as in a typical, pre-COVID19 pandemic prior season.<br><br>High Vaccine Effectiveness<br>- VE = 50% against medically attended influenza illnesses and hospitalizations (comparable to 2015-16 season). | Scenario B<br>Pessimistic flu prior immunity - Substantial impact of missed flu seasons due to the COVID-19 pandemic on prior immunity.*<br>- 50% lower immunity than a typical, pre-COVID19 pandemic season.<br><br>High Vaccine Effectiveness<br>- VE = 50% against medically attended influenza illnesses and hospitalizations (comparable to 2015-16 season). |
| Low Vaccine Effectiveness | Scenario C<br>Optimistic flu prior immunity - No impact of missed flu seasons due to the COVID-19 pandemic on prior immunity.*<br>- Same amount of prior immunity as in a typical, pre-COVID19 pandemic prior season.<br><br>Low Vaccine Effectiveness<br>- VE = 30% against medically attended influenza illnesses and hospitalizations (comparable to 2018-19 season). | Scenario D<br>Pessimistic flu prior immunity - Substantial impact of missed flu seasons due to the COVID-19 pandemic on prior immunity.*<br>- 50% lower immunity than a typical, pre-COVID19 pandemic season.<br><br>Low Vaccination Protection<br>- VE = 30% against medically attended influenza illnesses and hospitalizations (comparable to 2018-19 season). |

https://fluscenariomodelinghub.org/viz.html



# Combined – COVID-19 and Influenza

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios

- COVID-19 Scenarios – Round 16

| | |
|---|---|
| ☑ **Scenario A**<br>High boosters<br>Moderate immune escape variant<br>(A-2022-10-29) | ☑ **Scenario B**<br>High boosters<br>High immune escape variant<br>(B-2022-10-29) |
| ☑ **Scenario C**<br>Low boosters<br>Moderate immune escape variant<br>(C-2022-10-29) | ☑ **Scenario D**<br>Low boosters<br>High immune escape variant<br>(D-2022-10-29) |

- Influenza Scenarios – Round 2

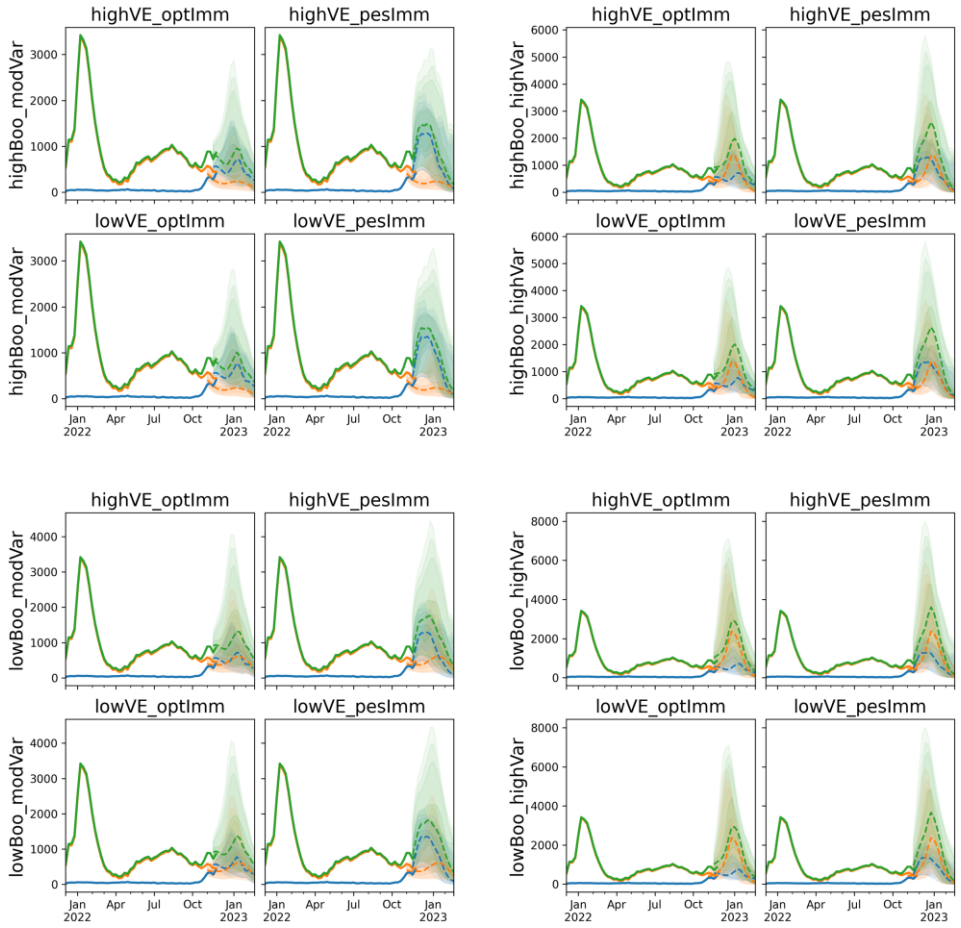
| | |
|---|---|
| ☑ **Scenario A**<br>High vaccine effectiveness<br>optimistic immunity<br>(A-2022-11-13) | ☑ **Scenario B**<br>High vaccine effectiveness<br>pessimistic immunity<br>(B-2022-11-13) |
| ☑ **Scenario C**<br>Low vaccine effectiveness<br>Optimistic immunity<br>(C-2022-11-13) | ☑ **Scenario D**<br>Low vaccine effectiveness<br>pessimistic immunity<br>(D-2022-11-13) |

Round 16 of COVID-19 is published while Round 2 of Influenza is still in a preliminary result stage

**Combined Hospitalizations (VA)**

UVA submissions only

VA - Flu Round 2 - COVID Round 16




COVID -19 scenarios and most “pessimistic” influenza scenarios combined

# Key Takeaways

Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

- VA weekly case rate is steady at 73/100K from 72/100K
  - US weekly case rate is flat remaining at 76 per 100K from 73 per 100K, though hospitalizations continue a steady rise
- VA hospital occupancy is quickly rising (rolling 7 day mean of 488 from 464 a week ago)
  - Influenza weekly hospital admissions remain high (~300 a week) and are approaching parity with COVID admissions (~40% of the combined)
- Projections anticipate increases in cases and hospitalizations in coming weeks
  - Combined hospitalizations due to Influenza and COVID-19 though are expected to level off
- Model updates:
  - Variant X candidates have now surpassed 50% (BQ.1.1, BN.1, BF.7 and others and XBB among others), 50% remains at Nov 12$^{th}$
  - Modified Booster Scenarios: Current pace (included in all scenarios) with comparisons between keeping the pace (which is slowing) and a more Pessimistic scenario where vaccination halts at current levels

The situation continues to change. Models continue to be updated regularly.

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Biocomplexity Institute. COVID-19 Surveillance Dashboard. https://nssac.bii.virginia.edu/covid-19/dashboard/

Google. COVID-19 community mobility reports. https://www.google.com/covid19/mobility/


Biocomplexity page for data and other resources related to COVID-19: https://covid19.biocomplexity.virginia.edu/

# Questions?

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